

# **Hezbollah: The Dynamics of Recruitment**

**A Monograph  
by  
Major Leroy Bryant Butler  
United States Marine Corps**



**School of Advanced Military Studies  
United States Army Command and General Staff College  
Fort Leavenworth, Kansas**

**AY 2011-01**

|   |   |   |   |  |
|---|---|---|---|--|
| <b>REPORT DOCUMENTATION PAGE</b>  |   |   | <i>Form Approved</i><br><i>OMB No. 074-0188</i>           |  |
| Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503   |   |   |   |  |
| <b>1. AGENCY USE ONLY</b><br>(Leave blank)  | <b>2. REPORT DATE</b><br>12 May 2011                                    | <b>3. REPORT TYPE AND DATES COVERED</b><br>SAMS Monograph, June 2010-May 2011 |   |  |
| <b>4. TITLE AND SUBTITLE</b><br>Hezbollah: The Dynamics of Recruitment  |   | <b>5. FUNDING NUMBERS</b>   |   |  |
| <b>6. AUTHOR(S)</b><br>Major Leroy Bryant Butler, USMC  |   |   |   |  |
| <b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b><br>School of Advanced Military Studies (SAMS)<br>250 Gibbon Avenue<br>Fort Leavenworth, KS 66027-2134   |   | <b>8. PERFORMING ORGANIZATION<br/>REPORT NUMBER</b>                           |   |  |
| <b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b><br><br>Command and General Staff College<br>731 McCellan Avenue<br>Fort Leavenworth, KS 66027-2134   |   | <b>10. SPONSORING / MONITORING<br/>AGENCY REPORT NUMBER</b>                   |   |  |
| <b>11. SUPPLEMENTARY NOTES</b>  |   |   |   |  |
| <b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b><br>Approved for Public Release; Distribution Unlimited  |   |   | <b>12b. DISTRIBUTION<br/>CODE</b>                         |  |
| <b>13. ABSTRACT (Maximum 200 Words)</b><br>Hezbollah, a successful terrorist organization, has survived over a 28 year period by creating and extending its mobilization base through its recruitment process. The purpose of this monograph is to examine Hezbollah's recruitment process combining the strengths of political science and mathematical modeling communities to the dynamics of terrorist recruitment. The novel contributions of this monograph are: [1] addresses an area seldom examined in terrorism research, the dynamics of recruitment; [2] blends techniques from deterministic mathematical modeling with qualitative techniques from the political science discipline; and [3] provides a novel model of recruitment based on enzyme kinetic dynamics. The monograph's four useful findings to the military researcher are: [1] the indirect approach is more likely to degrade a recruiter's ability to recruit than the direct approach of targeting the recruiter; [2] reducing the following parameters (in order of preference) contribute to the degradation of the recruiter's ability to conduct the recruitment process: non-suicide violence, education, and then the numbers of recruiters; [3] highlights logistic growth as a driver of adaptation for Hezbollah's recruitment process; [4] illustrates the utility of using the logistic growth model to estimate the potential recruitment pool of Shiite youths in the absence of validated data. |   |   |   |  |
| <b>14. SUBJECT TERMS</b><br>Terrorist Recruitment, Dynamical Systems, Hezbollah, Michaelis-Menten, Sensitivity Analysis, Nonlinear Differential Equations   |   |   | <b>15. NUMBER OF PAGES</b><br>60                          |  |
|   |   |   | <b>16. PRICE CODE</b>                                     |  |
| <b>17. SECURITY<br/>CLASSIFICATION<br/>OF REPORT</b><br>UNCLASSIFIED  | <b>18. SECURITY<br/>CLASSIFICATION<br/>OF THIS PAGE</b><br>UNCLASSIFIED | <b>19. SECURITY<br/>CLASSIFICATION<br/>OF ABSTRACT</b><br>UNCLASSIFIED        | <b>20. LIMITATION OF<br/>ABSTRACT</b><br><br>UNCLASSIFIED |  |

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)  
Prescribed by ANSI Std. Z39-18

Approved for Public Release; Distribution is Unlimited

# **SCHOOL OF ADVANCED MILITARY STUDIES**

## **MONOGRAPH APPROVAL**

Major Leroy Bryant Butler

Title of Monograph: Hezbollah: The Dynamics of Recruitment

Approved by:

\_\_\_\_\_  
Alexander J. Ryan, Ph.D.

Monograph Director

\_\_\_\_\_  
John C. DeJarnette, COL, EN

Second Reader,  
School of Advanced  
Military Studies

\_\_\_\_\_  
Wayne W. Grigsby, Jr., COL, IN

Director,  
School of Advanced  
Military Studies

\_\_\_\_\_  
Robert F. Baumann, Ph.D.

Director,  
Graduate Degree  
Programs

Disclaimer: Opinions, conclusions, and recommendations expressed or implied within are solely those of the author, and do not represent the views of the US Army School of Advanced Military Studies, the US Army Command and General Staff College, the United States Army, the Department of Defense, or any other US government agency. Cleared for public release: distribution unlimited.

## **Abstract**

HEZBOLLAH: THE DYNAMICS OF RECRUITMENT by Major Leroy Bryant Butler, USMC, 54 pages.

Hezbollah, a successful and respected terrorist organization, has survived over a 28 year period by creating and extending its mobilization base. Hezbollah's recruitment process has contributed to its successful growth. However, little is known about the recruitment processes employed by this organization. There is little to no data available, except for those figures published by Hezbollah through their formal communications. The purpose of this monograph is to examine Hezbollah's recruitment process combining the strengths of political science and mathematical modeling communities by applying qualitative analysis and quantitative modeling to the dynamics of terrorist recruitment. The novel contributions of this monograph are: [1] it addresses an area seldom examined in terrorism research, the dynamics of recruitment; [2] it blends techniques from deterministic mathematical modeling with qualitative techniques of case study analysis from the political science discipline; and [3] it provides a novel model of recruitment based on enzyme kinetic dynamics.

The results of this monograph comprise four findings that may be useful to the military researcher. The first finding suggests that the indirect approach is more likely to degrade a recruiter's ability to recruit than the direct approach of targeting the recruiter. Building on the first finding, the second finding implies that reducing the following parameters (in order of preference) contribute to the degradation of recruiter's ability to conduct the recruitment process: non-suicide violence, education, and then the numbers of recruiters. The third finding highlights logistic growth as a driver of adaptation for Hezbollah's recruitment process. Building on the third finding, the fourth finding illustrates the utility of using the logistic growth model to estimate the potential recruitment pool of Shiite youths in the absence of validated data – approximately 1 in 12 eligible Shiite youths joined Hezbollah.

## Table of Contents

|  |    |
|--|----|
| Abstract .....   | ii |
| Illustrations .....                                    | iv |
| Figures .....  | iv |
| Tables .....   | iv |
| Introduction .....                                     | 1  |
| Literature Review .....                                | 5  |
| Statistical Models of Terrorism .....                  | 5  |
| Deterministic Models of Terrorism .....                | 10 |
| Hezbollah .....  | 15 |
| A History of Hezbollah Recruiting .....                | 22 |
| The Recruitment Process .....                          | 24 |
| Modeling .....   | 31 |
| Research Question .....                                | 31 |
| Hypothesis .....                                       | 31 |
| Model Construction .....                               | 32 |
| Analysis .....   | 37 |
| Time Graphs .....                                      | 37 |
| Sensitivity Analysis: Phase Space Graphs .....         | 40 |
| Sensitivity Analysis: Parameter Variation .....        | 45 |
| Conclusion .....                                       | 48 |
| Recommendations .....                                  | 49 |
| Monograph's Major Contributions and Implications ..... | 50 |
| Future Research .....                                  | 50 |
| Final Thoughts .....                                   | 51 |
| BIBLIOGRAPHY .....                                     | 52 |

## Illustrations

### Figures

|   |    |
|---|----|
| Figure 1. Concentration over time for the Michaelis-Menten equations.....   | 38 |
| Figure 2. Hezbollah recruitment populations over time.....  | 39 |
| Figure 3. (a) Phase Plot, initial value of $X_2(0)=1$ for the Recruiters $X_2$ ; (b) $X_i$ over Time for $X_2(0)=1$ .....   | 42 |
| Figure 4. (a) Phase Plot, initial value of $X_2(0)=2$ for the Recruiters $X_2$ ; (b) $X_i$ over Time for $X_2(0)=2$ .....   | 43 |
| Figure 5. (a) Phase Plot, initial value of $X_2(0)=20$ for the Recruiters $X_2$ ; (b) $X_i$ vs. Time for $X_2(0)=20$ .....  | 44 |
| Figure 6. (a) Phase Plot, initial value of $X_2(0)=40$ for the Recruiters $X_2$ ; (b) $X_i$ over Time for $X_2(0)=40$ ..... | 45 |
| Figure 7. Sensitivity Analysis, 90% of Final Radical Population over Time.....  | 48 |

### Tables

|  |    |
|--|----|
| Table 1. Sensitivity Analysis from NetLogo Run. .... | 47 |
|--|----|

## Introduction

Hezbollah, otherwise known as “The Party of God,” developed from a humble resistance organization to a complex political organization that contains terrorist elements.<sup>1</sup> Hezbollah, initially created out of necessity to protect the Shiite population in Southern Lebanon against the Israeli Defense Force (IDF) in 1982, has truly become a “political and military powerhouse.”<sup>2</sup> On June 5, 1982, Israel invaded Lebanon after an eleven-month cease-fire with the Palestinian Liberation Organization (PLO) under the assumption that the PLO was involved in the unsuccessful assassination attempt of Shlomo Argov, the Israeli ambassador to the United Kingdom.<sup>3</sup> Ariel Sharon, then the Israeli defense minister, envisioned installing a second compliant Arab government in Beirut that would have entered into a ratified peace agreement with Israel.<sup>4</sup> Unbeknownst to Israel prior to their incursion into southern Lebanon, the state of Lebanon was already in political turmoil due to the diverse political and religious composition of its people. Since Lebanon’s independence from France in 1943, “an unwritten understanding between the dominant political communities of the day—the Sunni Muslims and the Maronite Christians” dictated the political agenda without much regard for the Shi’a Muslims within Lebanon.<sup>5</sup> Additionally, the Maronites and the Sunnis missed an opportunity to create an independent Damascus that was free from European and Syrian intervention due to their inability to comply with and promote the Arab nationalists’ concept of an “Independent State.”<sup>6</sup> After Sharon pushed the Israeli Defense Force (IDF) into southern Lebanon in 1982, Hezbollah was

---

<sup>1</sup> Eitan Azani, *Hezbollah: The Story of the Party of God: from Revolution to Institutionalization* (New York, NY: Palgrave MacMillan, 2008), ix-x.

<sup>2</sup> Nicholas Blanford, “Introduction,” in *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*, ed. Nicholas Noe, trans. Ellen Khouri, (New York, NY: Verso, 2007), 1.

<sup>3</sup> Augustus Richard Norton, *Hezbollah: A Short History* (Princeton, NJ: Princeton University Press, 2007), 32.

<sup>4</sup> Ibid., 33.

<sup>5</sup> Ibid., 11.

<sup>6</sup> Ibid.

created. The former Israeli Prime Minister Ehud Barak stated in July 2006, “When we entered Lebanon ... there was no Hezbollah. We were accepted with perfumed rice and flowers by the Shi’a in the south. It was our presence there that created Hezbollah.”<sup>7</sup> Fast forward 28 years, Hezbollah is a viable, thriving, and adaptable organization that consists of multiple components - social, military, political, and informational. This terrorist organization appears to be maintaining its 28 year long run with no end in sight.

In *How Terrorist Groups End*, Jones and Libicki posit, “[a]ll terrorist groups eventually end.”<sup>8</sup> The authors suggest that these organizations end due to “policing, military force, splintering, politics, or victory.”<sup>9</sup> In the case of Hezbollah, 28 years have passed and this organization has managed to survive by adapting to its environment and maintaining a robust mobilization base to counter Israeli/Lebanese policing, Israeli military forces, Syrian/Iranian politics, and perceived threats from Western States, such as the U.S. Since its inception in 1982, Hezbollah’s mobilization base of funding and education was sourced from the external state of Iran.<sup>10</sup> The source of personnel came from within the Shiite community in Southern Lebanon, which provided Hezbollah with the means to achieve the organization’s immediate ends of resistance to the occupation of Israeli Defense Forces, and maintaining the resistance movement

---

<sup>7</sup> Ehud Barak, Interview, Newsweek, (July 18, 2006), quoted in Augustus Richard Norton, *Hezbollah: A Short History*, (Princeton, NJ: Princeton University Press, 2007), 33; Sean Hannity and Alan Colmes, “Barak: Israel’s Presence in Lebanon Produced Hezbollah - Hannity - FoxNews.com,” *FOXNews.com*, ed. Voxant Inc, (July 26, 2006), <http://www.foxnews.com/story/0,2933,205726,00.html> (accessed March 30, 2011). The original source, the Newsweek webinar, is no longer available with Prime Minister Ehud Barak’s exact quote. This website provides a transcript, several days after the original source, of Prime Minister Barak’s comments that closely support the original statement quoted in Norton’s book.

<sup>8</sup> Seth G. Jones and Martin C. Libicki II, *How Terrorist Groups End: Lessons for Countering al Qaeda* (Pittsburgh, PA: RAND Corporation, 2008), xiii.

<sup>9</sup> *Ibid.*, 10.

<sup>10</sup> Naim Qassem, *Hizbullah: The Story from Within*, trans. Dalia Khalil (London: Saqi, 2005), 21; New TV, “Interview with New TV,” in *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*, ed. Nicholas Noe, trans. Ellen Khouri (New York, NY: Verso, 2007), 407.



against oppression within the state of Lebanon.<sup>11</sup> Hezbollah's efforts to generate and maintain a robust mobilization base through the recruitment process is the most critical element contributing to its operational success over the 28 year period. By maintaining their operational capability and durability, this organization has not culminated and has achieved two of their three long-term goals of expulsion of Israeli Defense Forces and the departure of western nations from Lebanon, with the third goal, the creation of an Islamic state, remaining.<sup>12</sup>

The recruitment process is defined in this paper as the selection and education of new members by recruiters, which consists of a diverse, social-economic population of trained Shiite agents and Shi'a clerics trained under Iranian religious influences. Hezbollah's key recruitment goal is to maintain "Islamic resistance units for the liberation of the occupied territories and for the expulsion of the aggressive [Israeli] forces."<sup>13</sup> To examine the role and significance of the recruiter given limited data, a combined research approach utilizing quantitative and qualitative techniques must be used to determine possible levers to decrease or increase a terrorist recruiter's ability to conduct recruitment operations. This monograph addresses the dynamics of terrorist recruitment by using Hezbollah as the organization of study, and the role of the recruiter, like a catalytic enzyme, catalyzing the recruitment and transformation process of Shiite youths into radical jihadists. The quantitative component will consist of constructing a dynamical systems model of terrorist recruitment. The qualitative component will consist of a historical analysis of Hezbollah's origins, ideology, and operations.

---

<sup>11</sup> Eitan Azani, *Hezbollah: The Story of the Party of God: from Revolution to Institutionalization*, 51, 61.

<sup>12</sup> U.S. Department of Commerce, *Near East/South Asia Report Lebanon: Hizballah Issues 'Open Letter' on Goals, Principles*, Foreign Broadcast Information Service (Springfield, VA: National Technical Information Service, 19 April 1985), 6.

<sup>13</sup> Hezbollah, "Statement of Purpose," *Hizballah-Lebanon-Al Mashriq* (March 20, 1998), <http://almashriq.hiof.no/lebanon/300/320/324/324.2/hizballah/statement01.html> (accessed January 16, 2011).

This monograph addresses the following questions based on the combined approach of study. What is the role of the recruiter, specifically how is the rate of recruitment related to the initial conditions and key environmental variables? What levers are available to counterterrorist forces to disrupt and degrade terrorist recruitment? What is the dynamical relationship between the disaffected population (the source of new insurgents), and the radical insurgent population (the final product of recruitment)? How can the dynamics of a terrorist organization's recruitment operations be modeled as a set of coupled ordinary differential equations? By modeling the interactions between key parameters affecting recruitment, this study attempts to provide insights into how to degrade the recruiter's effectiveness and efficiency, which may limit Hezbollah's growth. Specifically, by examining how effective or ineffective the cooperative components of funding, education, and violence are to Hezbollah's recruiters throughout the recruitment process, this study will provide insights into how to render other terrorist organizations ineffective in their ability to train, organize, equip, and operate in a complex environment.

This monograph is organized into four sections. Section 2, Literature Review, provides the reader with an overview of previous mathematical methods applied to the study of terrorism and terrorist organizations. Additionally, this chapter provides the reader with an overview of key studies on the Hezbollah organization and the results of these studies. Section 3, A History of Hezbollah Recruiting, provides the reader with a synopsis of Hezbollah's beginnings, early transformations, and key leaders. This chapter also explores the relationships between Lebanon, Israel, and Iran. This section explains the foundational social, political, and religious issues, which are critical to understanding the recruiting environment of the Hezbollah organization and the model introduced in Section 4, Modeling. Section 4 explains and describes the base equations used to develop a dynamical systems model of Hezbollah's recruitment processes. This section briefly explains and identifies the variables in this system, provides a brief analysis of the plots and phase space graphs, and gives a general synthesis of the results. Section 5, Conclusion,

examines the contributions and implications of the research presented in this monograph. This chapter will conclude with suggestions for future research on this topic.

## **Literature Review**

There are many techniques for examining a terrorist organization. There are studies that examine their command and control structure, their ability to sustain themselves, the influence of state support to an organization, how terrorist organizations end, and the effect of policing/military counterterrorism operations on these organizations. Just as there are many components of these organizations to study, there are a multitude of methodologies to examine these relationships and interactions based on the discipline studying them. The method used is influenced by the goal of the research – probabilistic correlations of specific variables that examine the parts of a system, or flows and behavior of a system as a whole. This monograph will focus on the latter, the flows and behavior of a system as a whole. Stochastic and deterministic approaches will be reviewed below to provide the reader with a broad introduction of these techniques.

### **Statistical Models of Terrorism**

Political scientists often favor stochastic methods for the study of terrorism. In contrast, there is a body of research, mostly performed by applied mathematicians, which develops deterministic models of terrorism. However, both approaches have had difficulty in producing predictive contributions to the study of terrorism. Because terrorist organizations consist of people, who think and act based on their beliefs, desires and intentions, as well as in response to stimuli in their environment, applying quantitative methods to unquantifiable, complex actors is problematic—especially in an open system environment. Uncertainties in these actions, amplified

by human thought are “rooted in values and motivations” and can never be predicted with certainty.<sup>14</sup>

Most of the research from the political science discipline examined terrorist organizations as actors in civil wars<sup>15</sup> with stochastic processes. Tilly claims that “political analysts have commonly considered violent interaction as marginal (or even antithetical) to politics ....”<sup>16</sup> Simply stated, the violence used by terrorist organizations, although heinous and destructive to a state, is nothing more than the means to an end, and is extremely similar to those actions in a civil war. Sambanis asserts violence induced by terrorists “can be a strategy during a civil war or a distinct form of violence with limited goals, designed to punish the state or seek revenge for prior abuses by the state.”<sup>17</sup> “Terrorism can have merely symbolic value, or it can be part of a revolutionary strategy with clearly defined political goals.”<sup>18</sup> This typology is similar to that of civil wars, since the induction of collective violence stems from a response to those deficiencies and/or atrocities committed by the state, in the attempt to gain more desirable conditions for the populace.

Collier, Hoeffler, and Sambanis have pioneered the political science approach to studying this topic with their research, especially “The Collier-Hoeffler Model of Civil War Onset and the

---

<sup>14</sup> Dietrich Dorner, *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations*, trans. Rita Kimber and Robert Kimber (Cambridge, MA: Perseus Books, 1996), 8.

<sup>15</sup> Charles Tilly, “The Politics of Collective Violence,” (2003), <http://catdir.loc.gov/catdir/samples/cam034/2002074067.pdf> (accessed March 20, 2011), 16-18. The Political Science discipline, when studying conflict, tends to group collective violence for a political aim in a few categories: interstate war, civil war, revolution, or rebellion. Terrorism does not fall in one of the typologies, since it can be viewed as those actions conducted by an individual or a group of individuals for individual or organizational goals based on emotions, not as a collective response to social processes.

<sup>16</sup> Tilly, “The Politics of Collective Violence,” 18.

<sup>17</sup> Nicholas Sambanis, “Terrorism and Civil War,” in *Terrorism, Economic Development, and Political Openness*, ed. Philip Keefer and Norman Loayza (New York, NY: Cambridge University Press, 2008), 201.

<sup>18</sup> Sambanis, “Terrorism and Civil War,” 201.

Case Study Project Research Design.”<sup>19</sup> The authors use a combination of qualitative analysis and quantitative analysis to develop a theory of civil war.

The Collier-Hoeffler empirical model “analyzes civil war and rebellion in terms of motive and opportunity, but focuses on opportunity as the determining factor of the rebellion.”<sup>20</sup> The authors use an “econometric model of civil war onset,” which analyzes those measurable economic variables of a state such as its annual Gross Domestic Product (GDP) and GDP Growth, to determine if there was a correlation among these variables.<sup>21</sup> The object of this type of analysis is to determine if there is a “difference from motive and opportunity in 78 civil wars between 1960 and 1999.”<sup>22</sup> The mathematical method used to determine if there are correlations amongst these variables is the stochastic method of logistical linear regression analysis.<sup>23</sup> The Collier-Hoeffler model “suggest[s] a plausible microlevel theory on civil war, but it is tested empirically with macrolevel data to describe conditions under which individual decision making takes place.”<sup>24</sup> Empirically, the CH model does not test a microlevel theory of civil war.<sup>25</sup> To address this gap in their methodology, the authors use a qualitative method of comparison case study analysis.

The authors focus on 22 cases studies out of 30 civil wars focused on “process tracing.”<sup>26</sup> This method of analysis is oriented on those “mechanisms through which the right-hand-side variables (the *X*’s) influence the dependent variable (*Y*) and ... [the exploration of the]

---

<sup>19</sup> Paul Collier, Anke Hoeffler, and Nicholas Sambanis, “The Collier-Hoeffler Model of Civil War Onset and the Case Study Project Research Design,” Vols. II: Europe, Central Asia, and Other Regions, chap. 1 in *Understanding Civil War: Evidence and Analysis*, edited by Paul Collier and Nicholas Sambanis, (Washington, DC: The World Bank, 2005), 1-34.

<sup>20</sup> Ibid., 3.

<sup>21</sup> Ibid., 19.

<sup>22</sup> Ibid., 3.

<sup>23</sup> Ibid., 19.

<sup>24</sup> Ibid.

<sup>25</sup> Ibid.

<sup>26</sup> Ibid.

interrelationships among the X's (interaction effects)."<sup>27</sup> These analyses or "structured-focused comparisons" were developed into narratives to assist in the explanation of "how the variables used in the empirical tests influence the probability of civil war."<sup>28</sup> The authors surmised that these "context-rich narratives of historical processes can provide insight into the causal paths linking independent variables in the Collier-Hoeffler model to civil war outbreak and can help disentangle complicated multicausal relationships."<sup>29</sup>

While terrorism and civil war are often conflated in the political science literature, some authors do distinguish between the two phenomena. One such study offering this viewpoint is found in *Terrorism, Instability, and Democracy in Asia and Africa* by Cox, Falconer, and Stackhouse. Cox *et al.* examine 29 years of terrorism activity in Asian and African states, and attempt to explain why terrorism occurs as a function of the product of democracy, cultural factors, poverty, and regional instability.<sup>30</sup> The authors perform linear regression analysis of coded Memorial Institute for the Prevention of Terrorism-Terrorism Knowledge Base (MIPT-TKB) data and qualitative case studies as a methodology.<sup>31</sup> Cox *et al.* assert, "... anything that produces great instability in society can provide a strong foundation for a sustained terror movement."<sup>32</sup> However, the authors do argue that, "... it is incumbent for any definition of terrorism that the targets be clearly defined as civilian."<sup>33</sup> They claim that the targeting of

---

<sup>27</sup> Collier...[et al], "The Collier-Hoeffler Model of Civil War Onset and the Case Study Project Research Design," 19.

<sup>28</sup> Ibid.

<sup>29</sup> Ibid.

<sup>30</sup> Dan G. Cox, John Falconer, and Brian Stackhouse, *Terrorism, Instability, and Democracy in Asia and Africa* (Lebanon, NH: Northeastern University Press, 2009), 4-5.

<sup>31</sup> Ibid., 1.

<sup>32</sup> Ibid., 5.

<sup>33</sup> Ibid., 19.

governmental and military infrastructure/personnel constitutes insurgent or rebellious activity, and should not be classified as a terrorist act.<sup>34</sup> Cox *et al.* formally define terrorism as:

Any premeditated violent act perpetrated against civilian noncombatants by subnational or international groups, clandestine agents, or individuals sympathetic to larger terrorist groups and movements, with the intent to influence a target audience larger than the intended victims toward or against a particular policy action.<sup>35</sup>

The authors conclude that three of the four factors, the lack of democracy, cultural differences, and poverty, moderately contribute to “specific states’ and specific terror groups’ motivations;” however, the most important factor appears to be instability.<sup>36</sup> The research suggests that instability “provides chaos that terror groups can exploit to recruit members and community support.”<sup>37</sup>

Another example of stochastic analysis applied to the study of terrorist organizations is the study by Jones and Libicki, “How Terrorist Groups End: Lessons for Countering al Qa’ida.” These authors conduct a temporal study of 648 terrorist organizations from 1968 to 2006 attempting to correlate “the impact of economic conditions, regime type, size, ideology, and group goals” to groups’ disablements and/or inability to continue to conduct operations.<sup>38</sup> As did Collier, Hoeffler, and Sambanis, these authors use logistical linear regression analysis of specified variables from the RAND-MIPT Terrorism Incident database.<sup>39</sup> The authors conclude that a “two-front strategy” consisting of policing and intelligence operations “should be the backbone of U.S. efforts,” as well as a reduced U.S. military presence in “Muslim countries” to reduce terrorist recruitment.<sup>40</sup>

---

<sup>34</sup> Cox...[et al], *Terrorism, Instability, and Democracy in Asia and Africa*, 19.

<sup>35</sup> Ibid., 21.

<sup>36</sup> Ibid., 202.

<sup>37</sup> Ibid.

<sup>38</sup> Jones and Libicki, *How Terrorist Groups End: Lessons for Countering al Qa’ida*, 4.

<sup>39</sup> Ibid., 6.

<sup>40</sup> Ibid., 124-125.

The three war onset models indicate that there is a significant correlation between the reduction of violence and improving the stability in governments in degrading the recruiting environment for terrorist organizations. While this technique and subsequent variations are used extensively throughout both the social and physical sciences to establish probable correlations among variables, correlations are silent on the most important questions for the counter-terrorist: how and why? For insight into mechanisms and reasons behind terrorist recruitment, we will turn to deterministic models of terrorism.

## **Deterministic Models of Terrorism**

Mathematicians developed methodologies that attempt to describe and model the behavior of a terrorist organization. However, applying methods that rely on pure empirical inputs to yield an empirically supported conclusion that is devoid of context and predictive value is problematic. In the last decade, a number of mathematical methods from the systems sciences were used to analyze terrorist organizations.<sup>41</sup> These models attempted to explain the dynamics of terrorist organizations with the expectation that future research will provide predictive value to military and political leaders.

In “Understanding Terrorist Organizations with a Dynamic Model,” Gutfraind posits that “[dynamic models have great potential] for informing terrorism scholarship and counter terrorism policy making.”<sup>42</sup> Gutfraind addresses one of the major weaknesses of modeling systems – their

---

<sup>41</sup> Alexander Gutfraind, “Understanding Terrorist Organizations with a Dynamic Model,” *Studies in Conflict & Terrorism* (Routledge Taylor & Francis Group) 32 (2009): 45-59; T. Chamberlain, “Systems Dynamics Model of Al-Qa’ida and United States “Competition”,” *Journal of Homeland Security and Emergency Management* 43, no. 14 (2007): 1-23; Jonathan David Farley, “Evolutionary Dynamics of the Insurgency in Iraq: A Mathematical Model of the Battle for Hearts and Minds,” *Studies in Conflict & Terrorism* (Routledge Taylor & Francis Group) 30 (2007): 947-962; Firdaus Udwadia, George Leitmann, and Luca Lambertini, “A Dynamical Model of Terrorism,” *Discrete Dynamics in Nature and Society* (Hindawi Publishing Corporation) (2006): 1-32; Alvin M. Saperstein, ““The Enemy of My Enemy Is My Friend” Is the Enemy: Dealing with the War-Provoking Rules of Intent,” *Conflict Management and Peace Science* (Sage), (2004): 287-296.

<sup>42</sup> Gutfraind, “Understanding Terrorist Organizations with a Dynamic Model,” 45.



reductionism. “Because [model systems] rely on large simplifications of the underlying political phenomena” they are open to multiple interpretations due to insufficient data.<sup>43</sup> To counter this weakness, Gutfraind uses an example of research in complex biological systems, which uses modeling to lay the foundation for his research in terrorism. Gutfraind’s methodology is to create a very simple dynamic model of a terrorist organization from a “‘human resources’ point of view” that focused on “examining how the numbers of ‘leaders and foot soldiers’ in the organization change with time.”<sup>44</sup> Gutfraind is able to prove, in a general system, that his modeled terrorist organization, “would collapse if its strength and its pool of foot soldiers decline simultaneously.”<sup>45</sup> “In contrast, a simultaneous decline in its strength and its pool of leaders is often insufficient and short-termed” as well.<sup>46</sup> His conclusion is twofold: first, “mathematical models [provide a benefit] to elucidate the logical implications of empirical knowledge that was used to construct the model”, and second, “simplicity of the model is crucial to making the model useful.”<sup>47</sup>

In “Systems Dynamics Model of Al-Qa’ida and United States ‘Competition’,” Chamberlain, at the time of publication, asserted that “the current U.S. [counterterrorism] strategy is an effective approach to the global war on terrorism.”<sup>48</sup> “However, the model also predicts that, regardless of the U.S. strategy followed, al-Qa’ida will be able to conduct at least [three] additional terrorist attacks, resulting in at least 2,000 additional U.S. citizen deaths before 2010.”<sup>49</sup> Because the expected attacks have not been forthcoming, this demonstrates the limitations of existing techniques for predictive purposes. Chamberlain “uses an approach called

---

<sup>43</sup> Gutfraind, “Understanding Terrorist Organizations with a Dynamic Model,” 46.

<sup>44</sup> Ibid.

<sup>45</sup> Ibid., 45.

<sup>46</sup> Ibid.

<sup>47</sup> Ibid., 55.

<sup>48</sup> Chamberlain, “Systems Dynamics Model of Al-Qa’ida and United States “Competition”,” 1.

<sup>49</sup> Ibid.

system dynamics modeling to better understand how al-Qa'ida is able to 'produce' terrorists who are willing to risk and, at times, sacrifice their lives and then deploy these individuals to carry out terrorist attacks."<sup>50</sup> By graphically representing the cause and effect interactions of the al-Qa'ida terrorist organization through stock-flow diagrams and causal loop diagrams, Chamberlain was able to develop a "historical behavior pattern [for this organization]."<sup>51</sup> The author extends his analysis by applying these diagrams against current U.S. counterterrorism strategies, to include funding allocations for the Department of Defense, Department of Justice, Department of Transportation, and the Department of Homeland Security. Chamberlain concludes: "the results indicate that doing something, following either the Current [U.S.] Strategy or the [U.S.] Preventive strategy, is better than doing nothing at all (the Baseline Strategy)."<sup>52</sup>

In "A Dynamical Model of Terrorism," Udwaia *et al.* propose "a new paradigm for studying terrorism," by using dynamical system modeling to examine the "long-term dynamical evolution" of terrorists, susceptibles, and pacifists when direct military and policing interventions are executed.<sup>53</sup> The authors' methodology entails developing a "dynamical model of terrorism in terms of the dynamics of the population of individuals who engage in terrorist activities."<sup>54</sup> A nonlinear system of three equations, is solved for fixed points (solutions to the equations) enabling sensitivity analysis (the graphical representation of solutions along the curve in two or three-dimensions) to be conducted. Based on their examination of the graphs of flows around the determined fixed points, the authors' conclusion is "that a combination of military/police action and nonviolent intervention yields a fixed point with a lower terrorist population [than] with any

---

<sup>50</sup> Chamberlain, "Systems Dynamics Model of Al-Qa'ida and United States "Competition",," 1.

<sup>51</sup> Ibid.

<sup>52</sup> Ibid., 21.

<sup>53</sup> Udwaia...[et al], "A Dynamical Model of Terrorism," 1.

<sup>54</sup> Ibid., 2.

one of these interventions excluded.”<sup>55</sup> This study is the most comprehensive use of dynamical system analysis applied to terrorism research; however, the research is monadic, like most mathematical surveys in terrorism: limited in scope, breadth, and neglecting the basics of political science conflict-peace theory.

Applications of deterministic mathematical methods to study terrorism increased substantially since September 11, 2001. To date, few models yielded viable results that can be predictive in nature or provide probabilistic inferences about these organizations. Mathematical methods focused on developing “data mining tools for identifying terrorism suspects” by applying network analysis, graph theory, complex systems methodology, or dynamical systems modeling.<sup>56</sup> For example, complex systems models yielded information “that [emergent] patterns observed in terrorist violence are surprisingly universal across conflicts.”<sup>57</sup> “The frequency of severe terrorist events, numbers of casualties [has] a power-law distribution. The exponent depends on the conflict, but exponents from conflicts and insurgencies across the globe appear to be converging over time toward 2.5.”<sup>58</sup> The significance of this number is that it has been substantiated through various studies based on documented and observed data for terrorists and insurgent organizations. A power-law distribution relationship indicates that terrorist organizations do not operate in a centralized manner, but are a result of complex interactions of positive and negative feedback.<sup>59</sup> The existence of the power law relation in terrorism was not

---

<sup>55</sup> Udwardia...[et al], “A Dynamical Model of Terrorism,” 27.

<sup>56</sup> Alexander Gutfraind, “Terrorism as a Mathematical Problem,” (*SIAM News*, October 2009)

<sup>57</sup> Ibid.

<sup>58</sup> Aaron Clauset and Frederik W. Wiegel, “A Generalized Aggregation-Disintegration Model for the Frequency of Severe Terrorist Attacks” *arxiv.org* (January 25, 2010), [http://arxiv.org/PS\\_cache/arxiv/pdf/0902/0902.0724v2.pdf](http://arxiv.org/PS_cache/arxiv/pdf/0902/0902.0724v2.pdf) (accessed March 13, 2011); M. Tsvetovat, and K. M. Carley, “On Effectiveness of Wiretap Programs in Mapping Social Networks,” *Computational and Mathematical Organization Theory* (Springer Science + Business Media) 13, no. 1 (2007): 63-87.

<sup>59</sup> John H. Miller and Scott E. Page, *Complex Adaptive Systems: An Introduction to Computational Models of Social Life* (Princeton, NJ: Princeton University Press, 2007), 165-166. A power-law distribution implies that infrequent ‘large values’ are rarer than frequent ‘small values’. In a Gaussian distribution, a normal distribution, the infrequent ‘large value’ is considered an outlier since it resides beyond three

known in the political science community prior to the application of this stochastic technique.<sup>60</sup> Although this pattern is a statistical result, complex systems models provided a larger scale of resolution from which to discern relationships amongst various conflicts.

The three conflict models indicate that pure empirical analyses alone are insufficient to describe the how and why of terrorism recruitment. When examining the behavior of the system, the studies suggest that recruitment can be degraded by reducing the pool of recruits and level of violence based on variables that are important to the agents in the system. In the application of dynamical systems modeling, there are several techniques applied – “ordinary differential equations, control theory, and dynamic graphs.”<sup>61</sup> These techniques tend to focus on the interactions of agents and the system over ‘time and space.’<sup>62</sup> The observations of these systems in phase space or via a graph network yield substantial insight on the system as a whole. Overall, both deterministic and stochastic models have their strengths and weaknesses in conflict studies; however, their overall results are meaningless, if not informed and/or placed in context of the people and other organizations in the system. This study combines the strengths of political science and math modeling communities to conduct qualitative analysis and model building. Now that various modeling techniques have been introduced, an overview of the Hezbollah organization and its recruitment process is presented.

---

standard deviations from the mean. In a power distribution, the infrequent ‘large value’ exists on the tail of the probability distribution. An example of this distribution is terrorist attacks, which obey a power-law. The large magnitude event of 9/11 is explained by the same statistical distribution that accounts for the frequent suicide bombings in the Middle East. The implication of power-law statistics is that knowing the average sized event does not provide meaningful predictive information on future events.

<sup>60</sup> Alexander Gutfraind, “Terrorism as a Mathematical Problem,” (*SIAM News*, October 2009).

<sup>61</sup> Ibid.

<sup>62</sup> Ibid.

## Hezbollah

Hezbollah's first and most important statement is its "Open Letter on Goals, Principles" on February 15, 1985. "This letter was published on the first anniversary of the martyrdom of Raghīb Hard, the symbol of Islamic resistance and the paramount martyr."<sup>63</sup> Addressed to the "downtrodden in Lebanon and the world," it explained the organization's goals and direction of development in achieving those goals.<sup>64</sup> Hezbollah's three primary goals consist of the expulsion of Israeli Defense Forces, the departure of western nations from Lebanon, and the creation of an Islamic state.<sup>65</sup> This document intellectually links the Iranian revolutionary thought to Hezbollah's early ideological development:

We, the sons of [Hezbollah's] nation, whose vanguard God has given victory in Iran and which has established the nucleus of the world's central Islamic state, abide by the orders of a single wise and just command currently embodied in the supreme Ayatollah Ruhollah al-Musavi al-Khomeyni, the rightly-guided imam who combines all the qualities of the total imam, who has detonated the Muslims' revolution and who is bringing about the glorious Islamic renaissance.<sup>66</sup>

Hezbollah proceeded to publish additional documents that helped to refine its goals over time and to define its relationships with other Muslim nations. Another defining document conveying the overarching goals of Hezbollah in its formative years is the "Views and Concepts" document, publicized by Manawar TV station in Beirut in June 1997. This document provides insight into the slight shift in the rhetoric in relation to the basic goals of the organization. Hezbollah states in the first paragraph of this document "freedom, right, justice and peace are essential for any

---

<sup>63</sup> U.S. Department of Commerce, *Near East/South Asia Report Lebanon: Hizballah Issues 'Open Letter' on Goals, Principles*, 1. The author will use the following accepted, transliterated spelling of 'Hezbollah' from the Arabic words *hezb Allah*, the "party of God," throughout this monograph and will replace other spellings in accordance with Kate Turabian, *A Manual for Writers: of Research Papers, Theses, and Dissertations*, 7th ed. (Chicago, IL: Chicago University Press, 2007), 312.

<sup>64</sup> Ibid., 4-6.

<sup>65</sup> U.S. Department of Commerce, *Near East/South Asia Report Lebanon: Hizballah Issues 'Open Letter' on Goals, Principles*, 6.

<sup>66</sup> Ibid., 2.

society to rise and develop.”<sup>67</sup> However, Hezbollah perceives a difference in “achieving security and peace that are based on right and justice in Lebanon” while rejecting “all forms of aggression and terrorism.”<sup>68</sup> This statement was extremely telling about the ongoing shifts in thought and ideology within the organization, particularly because Hezbollah was attempting to develop a creditable political wing while waging an extremely complex and aggressive insurgency against Israeli Defense Force’s operations in southern Lebanon from May 2000 to April 2006. One deduction from this document was that Hezbollah was struggling with the decision of whether or not to endorse/sponsor insurgent/terrorist activities while attempting to become a legitimate political party, thereby risking its mobilization base.<sup>69</sup> Examining self-proclaimed ideologies and concepts through organizational communications have been extremely useful to understanding the Hezbollah organization. However, other comparative analyses of Hezbollah examine existing religious tensions, social issues, organizational formation, and/or geopolitics of the region.

Most political science research methods used to examine Hezbollah have traditionally been comparative analyses of religious tensions, social issues, organizational formation, and/or geopolitics with Lebanese/Israeli historical actions, using formal Hezbollah organizational communications as evidence. Harik’s *Hezbollah: The Changing Face of Terrorism*, examines the “struggle between Hezbollah and the American administration over whether the former is a terrorist group or a resistance force fighting Israeli occupation.”<sup>70</sup> Harik’s thesis is that

---

<sup>67</sup> Hizbullah, *Hizbullah: Views and Concepts*, ed. Borre Ludvigsen. Ostfold College (June 20, 1997), <http://almashriq.hiof.no/lebanon/300/320/324/324.2/hizballah/hizballah-background.html> (accessed January 5, 2011).

<sup>68</sup> Ibid.

<sup>69</sup> Naim Qassem, *Hizbullah: The Story from Within*, trans. Dalia Khalil (London: Saqi, 2005), 314. Qassem summarizes the contentious issues regarding parliamentary representation by the twelve-member delegation of Hezbollah’s most prominent members. The issues focused on the legitimacy of holding seats in Parliament, the cost and benefits of participation, and would participation in Parliament affect Hezbollah’s original goals and vision for Lebanon.

<sup>70</sup> Judith Palmer Harik, *Hezbollah: The Changing Face of Terrorism*, 1st Paperback ed. (New York, NY: I. B. Tauris & Co. Ltd, 2005), 2.

“Hezbollah developed two major strategies to combat these charges and that the deliberate implementation of those strategies during the past decade has allowed the party to change its terrorist face.”<sup>71</sup> The first major strategy included pursuing a “military strategy against Israeli military forces inside Lebanon’s borders” in order to support the “removal of an illegal occupation.”<sup>72</sup> Because these actions occurred in Lebanese territories and were directed at military targets, they could not be defined as terrorism and Hezbollah was “elevated ... to almost heroic status in Lebanon and throughout the Arab and Muslim worlds.”<sup>73</sup>

The second major strategy that Hezbollah initiated was the “development of an interrelated political strategy that would sustain popular support . . . when Hezbollah’s hit-and-run missions were slowly taking their toll and beginning to provoke massive retaliations from Israel.”<sup>74</sup> Additionally, Hezbollah would have to persuade Lebanese citizens that it was “no longer a radical Islamic militia” and “its transformation into a mainstream Lebanese party was authentic rather than opportunistic” in order to maintain its support from the people.<sup>75</sup> Harik’s methodology involves the use of comparative analysis of strategic and foreign policy documents, Hezbollah’s organizational documents, and the “interrelationship, dynamics, and manifestations of the terrorist/resistance controversy.”<sup>76</sup> Harik’s conclusion is that Hezbollah’s existence and viability have proven that its strategies have enabled its long-term survival, and the United States, irrespective of terrorist classification, deem Hezbollah a threat to the Middle East region and United States soil.<sup>77</sup>

---

<sup>71</sup> Harik, *Hezbollah: The Changing Face of Terrorism*, 2.

<sup>72</sup> Ibid.

<sup>73</sup> Ibid.

<sup>74</sup> Ibid., 3.

<sup>75</sup> Ibid.

<sup>76</sup> Ibid., 4.

<sup>77</sup> Ibid., 194-195.

In contrast, Azani's *Hezbollah: The Story of the Party of God, from Revolution to Institutionalization*, views the organization as a social movement beset with internal/external turmoil. This provides the energy for revolutionary action, which the author characterizes as a, "complex social phenomena."<sup>78</sup> Azani states this model of revolutionary moment "that developed in Lebanon is unique and different due to the Lebanese ethnic sectarian structure, Lebanon's unique geopolitical condition, and the Shiite Islamic nature. Hezbollah was established at the peak of crisis in the Lebanese system."<sup>79</sup> Azani's methodology includes the examination of the in-flows and out-flows of three primary systems. "Hezbollah operates in the environment of three different systems: the Lebanese, the regional, and the international. These systems uphold complex and dynamic reciprocal relations between themselves that influenced and still influence the movement's directions of development."<sup>80</sup> Azani concludes that Hezbollah's "success, survival, and expansion" are due to "two basic elements:"

A. The regulative element is the ability to build an effective activity capability leaning on internal and external resources composed of efficient and hierarchical organization, military capability, funding, and the enforcement of organizational authority.

B. The legitimacy element, leaning on the organizational discourse, includes within itself dogmatic justifications for strategic changes carried out by the movement, the appropriation of Lebanese national responsibility, partial adjustment (if only seemingly), and willingness to operate in the framework of the existent Lebanese political system as an exception of evaluations of the situation, sensitivities to changes, and the influences of the sectarian public opinion.<sup>81</sup>

One of the most referenced and well-known text examining Hezbollah's organizational history, structure, and goals is Norton's *Hezbollah: A Short History*.<sup>82</sup> Norton attempts to

---

<sup>78</sup> Azani, *Hezbollah: The Story of the Party of God*, 1.

<sup>79</sup> Ibid., ix.

<sup>80</sup> Ibid., x.

<sup>81</sup> Ibid., 242.

<sup>82</sup> Norton, *Hezbollah: A Short History*, 5-6.



examine Hezbollah using a more holistic approach and looks beyond the initial violent actions of this organization. Norton's asserts "Hezbollah is not easily understood either by simplistic stereotypes that typically inform depictions of the organization in the newspapers and on the airwaves of the Western world nor by black and white worldviews."<sup>83</sup> "Hezbollah evolved from an Iranian-influenced conspiratorial terrorist group rejecting participation in Lebanese politics, to a party with considerable autonomy and a talent for playing politics and winning elections."<sup>84</sup> Norton states this "Janus-faced profile [of Hezbollah] infuriates detractors while seeming perfectly reasonable to its defenders and supporters," illustrating the complex environment that is both in opposition to and reinforcing this organization's existence.<sup>85</sup> Norton's methodology examines Hezbollah in its two primary roles throughout its existence, one as an "Iranian-influenced conspiratorial terrorist group" that rejects the politics of the Lebanese Parliament, and the other as "a party with considerable autonomy" capable of conducting successful political actions at all levels of government.<sup>86</sup> Norton conducts a temporal analysis of Hezbollah's development by using empirical evidence from Hezbollah's official organizational statements, official correspondence from the organization's leadership, and historical documents relating to the governance of Lebanon to support his assertion. Despite the fact that Hezbollah's involvement in defending southern Lebanon fueled a large proportion of the violence in Lebanon over time, Norton concludes that the "Shi'a would emerge from the [July 2006 war] as a mobilized, assertive, and more militant community."<sup>87</sup> Norton implies that Hezbollah's complex organizational nature enabled it to affect a multiplicity of political, social, and religious factors in

---

<sup>83</sup> Norton, *Hezbollah: A Short History*, 8.

<sup>84</sup> *Ibid.*, 6.

<sup>85</sup> *Ibid.*

<sup>86</sup> *Ibid.*

<sup>87</sup> *Ibid.*, 158.

Lebanon. “Hezbollah is clearly fated to play a continuing and important role” in the development of Lebanon.<sup>88</sup>

Additionally, there is a rigorous and well-researched text written from the perspective of a Party insider, who presents an in-depth examination of Hezbollah’s philosophy, organization, and goals. According to Qassem, the importance of Hezbollah to the Shiite Muslim population in Southern Lebanon is akin to the significance of Islam as the religion before Allah; Hezbollah exists to represent the interest of the oppressed Shiite Muslims via its “surrender to God’s will and guidance.”<sup>89</sup> Qassem’s *Hizbullah: The Story from Within* provides a very detailed and robust survey of the “[order’s]” goals, vision, and interpretation of Islamic law.<sup>90</sup> This text also provides an explanation of jihad and its significance to the “resistance project.”<sup>91</sup> Qassem’s methodology rigorously presents the characteristics of the resistance project, Hezbollah’s organization and public action, and lastly, Hezbollah’s important developmental milestones for the education of the reader.<sup>92</sup> Qassem concludes in his survey “the Party is no longer a concept presented for discussion, a programme that needs to win conviction. It has now transformed into a reality entrenched at the core of national events.”<sup>93</sup> Additionally, Hezbollah’s membership “was not limited to *jihad* or military groups, but expanded into social, political, and cultural fabric of the general population.”<sup>94</sup>

Lastly, Alagha’s *The Shifts In Hizbullah’s Ideology: Religious Ideology, Political Ideology, and Political Program* examines this organization through all four lens presented at the beginning of this section – religion, societal issues, organizational dynamics, and geopolitics.

---

<sup>88</sup> Norton, *Hezbollah: A Short History*, 159.

<sup>89</sup> Naim Qassem, *Hizbullah: The Story from Within*, trans. Dalia Khalil (London: Saqi, 2005), 11.

<sup>90</sup> *Ibid.*, 10.

<sup>91</sup> *Ibid.*, 11.

<sup>92</sup> *Ibid.*

<sup>93</sup> *Ibid.*, 428.

<sup>94</sup> *Ibid.*

Alagha's approach examines the organization as an "identity-based movement" that evolved from "propagating an exclusivist religious ideology; [to] a more encompassing political ideology; and [to] what can be considered a pragmatic political program."<sup>95</sup> Alagha asks how can "[Hezbollah] be faithful to its Islamic identity, on the one hand, and at the same time function as a mainstream political party working in a confessional-sectarian system, on the other?"<sup>96</sup> Alagha posits, "[Hezbollah] is going through a remarkable political and ideological transformation."<sup>97</sup> "[Hezbollah] has been adjusting its identity in the three [distinct stages] by shifting emphasis among its three components: (1) from propagating an exclusivist religious ideology; (2) to a more encompassing political ideology; and (3) to a down-to-earth political program."<sup>98</sup> Alagha concludes that "through this process of disenchantment [Hezbollah] has been able to create a balance between its Islamic identity and nationalist-patriotic dimension."<sup>99</sup> One theme common across the surveyed literature is the concept that "[Hezbollah] defines its identity as an Islamic *jihadi* movement, 'whose emergence is based on an ideological, social, political, and economic mixture in a special Lebanese, Arab, [Israeli], and Islamic context.'"<sup>100</sup> More recently, Hezbollah re-defined its identity as a "Resistance Party" with both military and political goals in securing the territory, sovereignty, and Lebanese populace in opposition to Israeli occupation and "U.S.-Western hegemony ... in the region."<sup>101</sup>

---

<sup>95</sup> Joseph Alagha, *The Shifts In Hizbullah's Ideology: Religious Ideology, Political Ideology, and Political Program* (De Kreeft: Amsterdam University Press, 2006), 13.

<sup>96</sup> Ibid., 12.

<sup>97</sup> Ibid., 373.

<sup>98</sup> Ibid.

<sup>99</sup> Ibid., 212-213.

<sup>100</sup> Hezbollah, "Identity and goals," website, (August 2004), [http://hizbollah.org/english/frames/index\\_eg.htm](http://hizbollah.org/english/frames/index_eg.htm), quoted in Joseph Alagha, *The Shifts In Hizbullah's Ideology: Religious Ideology, Political Ideology, and Political Program* (De Kreeft: Amsterdam University Press, 2006), 13.

<sup>101</sup> Sayyed Hassan Nasrallah, "Full speech of H. E. Sayyed Nasrallah : Hizbullah's New Political Manifesto.... We Want Lebanon Strong & United" (November 30, 2009),

Hezbollah's evolution from state sponsored terrorist organization to political party in Lebanon was made possible by its recruitment process. Hezbollah always required an influx of recruits to maintain its core competency of guerilla operations during its initial period of operations. As Israeli operations into Lebanon increased over time, and competing resistance organizations recruited from the same Shiite population, Hezbollah's threatened existence required a concerted recruitment effort to maintain functionality, organizational structure, and legitimacy.

## **A History of Hezbollah Recruiting**

The ideological foundations of Hezbollah originate prior to 1982 in southern Lebanon. The foundations for this organization were established out of the social and political grievances of the Lebanese Shiite population. A series of Arab-Israeli wars occurred from 1948 to 1978 that dramatically redefined the geographical borders of Palestine, Israel, Jordan, and Lebanon, which facilitated the ensuing resistance fighting from the Palestinian Liberation Organization (PLO), Hamas, and the Islamic Brotherhood. The 1978 Israeli invasion into southern Lebanon contributed the most to setting the conditions for the initial resistance groups, which would provide the leadership, ideology, and public support for Hezbollah by 1982. Israel reclaimed the Gaza strip and southern Lebanon during Operation LITANI in 1978 to create a security zone, preventing the PLO from conducting retaliatory rocket strikes against northern Israeli targets.<sup>102</sup> These border skirmishes created a hostile and destitute living area, which mobilized an already politically disenfranchised Shi'a minority to improve their situation. Musa al-Sadr "set out to establish himself as the paramount leader of the Shi'a community" and he encouraged the people

---

<http://www.english.moqawama.org/essaydetails.php?eid=9632&cid=231&st=Political Document> (accessed March 14, 2011).

<sup>102</sup> Alagha, *The Shifts In Hizbullah's Ideology*, 30.

to engage in a “social revolution.”<sup>103</sup> As Musa al-Sadr rallied the people of southern Lebanon to organize and resist Israeli occupation and the Lebanese government’s inability to protect and provide for the Shiite minority, he disappeared unexpectedly, leaving a void for other leaders to gain popular support for their respective view of the coming revolution. Sayyed Hassan Nasrallah was one of these leaders who also contributed to the establishment of Hezbollah.

Hezbollah traces its official beginnings to the summer of 1982, when Sayyed Hassan Nasrallah, the current leading cleric, left a sectarian militia “*Afwaj Al-Muquawama Al-Lubnaniyya* (‘The Brigades of the Lebanese Resistance’) ... [Amal],” due to his belief that the resistance against the Israeli Defense Force should be Islamicized.<sup>104</sup> “Hezbollah was established with the assistance of Iran, which dispatched a contingent of Iranian Revolutionary Guards to Bekaa.”<sup>105</sup> The Iranian Revolutionary Guards’ purpose was to recruit, train, and educate the future foot soldiers of the militant component of Hezbollah. Three critical factors helped galvanize the Lebanese Shiites in the formation of Hezbollah are: the 22-year occupation of southern Lebanon, the unexplained disappearance of Imam Musa Sadr in Libya in August 1978, and finally, the Iranian Revolution of February 1979 establishing Khomeini’s Islamic Republic.<sup>106</sup> Hezbollah announced their official existence in an “Open Letter,” a document that outlined their political aims and ideology.<sup>107</sup> The essence of the “Open Letter” was “to free Lebanon from the manipulation and chicanery of the malevolent outside powers in order to achieve ‘the final departure of America, France, and their allies from Lebanon and the

---

<sup>103</sup> Norton, *Hezbollah: A Short History*, 18.

<sup>104</sup> Alagha, *The Shifts In Hizbullah's Ideology*, 29; Blanford, “Introduction,” in *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*, 5.

<sup>105</sup> Blanford, “Introduction,” in *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*, 5.

<sup>106</sup> Ibid.

<sup>107</sup> Ibid.

termination of the influence of any imperialist power in the country.’’<sup>108</sup> For the religious Islamic right, “*wilayat al-faqih*, the creation of an Islamic republic on the Iranian model” was the end-state.<sup>109</sup> However to date, Hezbollah has not confirmed that this is truly the end-state of the organization. Regardless of its beginnings, the strategic goal of Hezbollah is the liberation of Palestine and Shiite areas in Southern Lebanon from Israeli control.

## The Recruitment Process

This section examines Hezbollah’s recruitment processes, specifically the history, basic tenants, and organization of trained recruits. From 1982 to 1985, Hezbollah’s leadership faced the problems of broadening the organization’s mobilization base and ensuring that the revolutionary movement remained a popular movement amongst the southern Shiite population.<sup>110</sup> Hezbollah quickly focused its efforts along three axes of effort:

The *ideological-religious*, with the aim of mobilizing society and incorporating into it motifs such as religious activism, resolve, and willingness for personal sacrifice for the sake of the whole; the *social*, with the aim of abolishing ethnic discrimination and social injustice and improving the living conditions of the Shiite population; and the *military*, with the aim of bringing about the expulsion of all foreigners from Lebanon.<sup>111</sup>

During this early stage of development, the recruitment process was heavily influenced by Iranian religious education, military education, an intense propaganda campaign, and financial support. The “Iranian Islamic Revolutionary Guard constituted the primary source of resistance fighters—or *mujahideen* – for the ‘Islamic Resistance’,” as well as assuming the roles of initial recruiters/training cadre.<sup>112</sup> As early as 1982, “many [Hezbollah] members participated in such training [activities] irrespective of their functional posts in the Party or assigned tasks, [since]

---

<sup>108</sup> Norton, *Hezbollah: A Short History*, 38.

<sup>109</sup> Ibid., 39.

<sup>110</sup> Azani, *Hezbollah: The Story of the Party of God*, 63.

<sup>111</sup> Ibid., 63.

<sup>112</sup> Qassem, *Hizbullah: The Story from Within*, 137.

training is a pre-requisite for Party membership.”<sup>113</sup> The results of this comprehensive training and education effort were the effective use of personnel and resources by Hezbollah to dislodge Israeli Defense Forces and multinational forces with surprising success in 1983. The resistance movement “was surprising in its innovativeness and the level of determination and sacrifice that characterized its attacks.”<sup>114</sup> As an example, Hezbollah used various levels of violence, specifically suicide bombings, to expel the Israeli Defense Forces and multinational forces from Lebanese territory. An example of a suicide attack inducing this type of dislodgement occurred in March 1983 “when Hezbollah members drove a truck filled with approximately 1,000 lbs of explosives next to an Israeli military convoy and detonated it.”<sup>115</sup> This incident yielded a mixture of dead and injured Hezbollah agents and Israeli Defense Force members, encompassing 120 individuals in all.<sup>116</sup> Subsequent examples include the April 1983 suicide bombing attack against the U.S. Embassy in Beirut, and the suicide bombing of the multinational forces’ barracks in Beirut in October 1983.<sup>117</sup> Anzani states, “[these] operations produced immediate results. Since [the Israeli and multinational forces] stay in Lebanon exacted ... a price higher than they were willing to pay, they left Beirut in the beginning of 1984.”<sup>118</sup> These early successes, in aggregate, provided the energy necessary to make the resistance movement attractive to the socially and economically disenfranchised, and popular amongst the middle and upper classes along ideological-religious lines. The resistance movement mobilized the disaffected Shiite population,

---

<sup>113</sup> Qassem, *Hizbullah: The Story from Within*, 137.

<sup>114</sup> Azani, *Hezbollah: The Story of the Party of God*, 66.

<sup>115</sup> Brian A. Jackson...[et al], *Aptitude for Destruction: Volume 2: Case Studies of Organizational Learning in Five Terrorist Groups*, vol. 2. 2 vols. (Santa Monica: RAND Corporation, 2005), 41.

<sup>116</sup> *Ibid.*, 41.

<sup>117</sup> Azani, *Hezbollah: The Story of the Party of God*, 66; Ahmad Nizar Hamzeh, *In the Path of Hizbullah*, 1st ed. (Syracuse, NY: Syracuse University Press, 2004), 82 table 5.1. See Table 5.1 for additional martyrdom operations data by Hezbollah from 1982 to 1983.

<sup>118</sup> Azani, *Hezbollah: The Story of the Party of God*, 66.

which became the source of potential recruits and establish the pacifist support base required for a developing terrorist organization.

Hezbollah's problems of expanding its mobilization base, as well as growing/maintaining popular support for the mobilization base were solved by the "combined social and religious propaganda activity and [by] initiating and leading violent action for the achievement of [the Party's] goals common to the entire community ...."<sup>119</sup> These actions resulted in "expanding the potential for recruitment and support of the movement."<sup>120</sup> Hezbollah continued to use this formula of social-religious awakening (education and propaganda) and violent actions to increase its recruitment from 1985 until the present. Hezbollah founder Abbas al-Musawi's efforts to organize the military infrastructure in southern Lebanon from 1985 to 1988 illustrate the adoption of these tenets (education, training, violence, and funding). In creating the 'Islamic Resistance,' he used previous "successes as a tool to recruit its ranks, to enhance the fighting spirit of its activists, and to strengthen the aspect of sacrifice and determination."<sup>121</sup> Hezbollah grew not only in southern Lebanon but also in all areas throughout Lebanon, especially during periods of intense conflict such as April 1996, May 2000, and June 2006 – specific periods that correlate with Israeli Defense Forces' deliberate offensive operations against Hezbollah and/or the Shiite population supporting Hezbollah. During these engagements, the energy expended to conduct such operations by Hezbollah returned to the Party in the form of additional operational capabilities by a supportive Shiite mobilization base.

The sources of Hezbollah's recruits encompass the entire social strata of the Shiite population from the economically depressed to the highly educated professional. Initially, the recruitment process focused on educating and training the male youths from the lower economic

---

<sup>119</sup> Azani, *Hezbollah: The Story of the Party of God*, 65.

<sup>120</sup> Ibid.

<sup>121</sup> Ibid.



stratum. Later as Hezbollah became more successful in its acts of violence, the focus of recruitment became those Shiite citizens from the “petty bourgeoisie or occupational clusters such as shopkeepers, small and medium-size businessmen, small landowners, professionals, teachers, and clerks who [were] opposed to the dilution of Islamic ethos under the impact of foreign political, economic, and social penetration.”<sup>122</sup> This population of potential recruits provided Hezbollah with not only an offensive, tactical capability, but also multiple defensive and sustainment capabilities to extend Hezbollah’s operational reach. This population provided specific medical, computer, engineering, and educational skills not possessed by the common combat recruit.<sup>123</sup> Hezbollah’s recruitment process, by design or not, created a task organization of personnel that enhanced its capabilities and resources over time. The Islamic Resistance’s combat section consisted of this amalgamation of recruited personnel: martyrs, commandos, rocket launchers/weapon specialists, and regular fighters/sustainment personnel.<sup>124</sup> The simultaneity of all efforts from this diverse organization has enabled Hezbollah to increase in size and scope, become a major opponent to Israel, and an international political body.

Hezbollah, as an organization, learned to recruit more effectively and efficiently by the selective retention of those operational tenets (education, non-suicide violence, suicide violence), which contributed to its greatest successes on the battlefield and in the hearts of the Shi’a population throughout Lebanon. Senge defines a ‘learning organization’ as “an organization that is continually expanding its capacity to create its future.”<sup>125</sup> Organizational learning can be modeled as a dynamical relationship where the individuals learn, adapt, and apply this new knowledge to their skill base to improve the performance of the organization. Adaptation, as a

---

<sup>122</sup> Hamzeh, *In the Path of Hizbullah*, 76-77.

<sup>123</sup> Ibid., 76.

<sup>124</sup> Ibid., 71.

<sup>125</sup> Peter M. Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization* Revised ed. (New York, NY: Currency Doubleday, 2006), 14.

process, implies that systems “change their behavior to improve their chances of survival or success—through learning or evolutionary processes.”<sup>126</sup> Additionally, the organization learns how to catalogue, integrate, and influence the way its individual members learn.<sup>127</sup> This complex, didactic system contains a multitude of variables, which make it difficult to predict, influence, and re-create since the organization can be affected by external conditions, as well as internal conditions.<sup>128</sup> The organization that can learn from its individuals, as they learn from their experiences, and can apply these new insights, techniques, and tactics can be successful in any setting – business, war, politics, or recruiting. Hezbollah is one such organization whose recruitment processes evolved through adaptive processes in its operations and tactics in order to remain a viable opponent of Israel, and a proponent for the welfare and safety for the Lebanese Shiites in Southern Lebanon.

Like most studies in terrorism, accurate and reliable data on terrorist organizations (sizes, strengths, and capabilities) are either non-existent or classified. Hezbollah is no different in this regard; however, it publishes official communications, which include the organizational vision, statements, real-time conflict reporting, and political initiatives. Hezbollah has not published specific organizational data regarding its size and disposition, yet other sources produced estimates based on inferences from these organizational communications. The estimated size of Hezbollah, as reported by several sources, suggests that Hezbollah’s initial fighting strength ranges from 500-2,000 full-time fighters, consisting of males in their late 20s and early 30s.<sup>129</sup>

---

<sup>126</sup> Melanie Mitchell, *Complexity: A Guided Tour* (New York, NY: Oxford University Press, 2009), 13.

<sup>127</sup> D. Miller, “A Preliminary Topology of Organizational Learning: Synthesizing the Literature,” *Journal of Management*, Vol. 22, no. 3, (1996): 485-505 quoted in Brian A. Jackson...[et al], *Aptitude for Destruction: Volume 1: Organizational Learning in Terrorist Groups and Its Implications for Combating Terrorism*, vol. 1. 2 vols, (Santa Monica, CA: RAND Corporation, 2005), 9.

<sup>128</sup> Ibid.

<sup>129</sup> The International Institute for Strategic Studies, “July 17th--BBC NEWS--Middle East Violence: Comparing Hezbollah and Israel's Military Strengths,” *International Institute for Strategic Studies Comparing Hezbollah and Israel's Military* (July 17, 2006) <http://www.iiss.org/whats-new/iiss-in->

Jane's World Insurgency and Terrorism database provides an estimate of 600 – 800 full-time fighters, and as many as 5,000 – 7,000 part-time fighters available to conduct resistance operations, with an additional estimated 25,000 reserve personnel.<sup>130</sup> Using the most conservative estimates from the previous sources (500 full-time fighters, 5,000 part-time fighters, and 25,000 reserve personnel); the estimated size of Hezbollah's core fighters is 30,500.

Another technique to determine the estimated size of Hezbollah's recruitment pool is to use demographic population data to derive an empirical estimate of the number of Shiite males available for recruitment. To simplify the estimates, two assumptions must be made explicit to the reader: Hezbollah is 100% Shiite and 100% male. The most accurate data for estimating the recruitment population is from the United Nations Department of Economics and Social Affairs/Population Division's *World Population Prospects: The 2008 Revision* for the state of Lebanon.<sup>131</sup> The estimated total population for Lebanon in 2009 is 4,224,000 and the percentage of the Shiite population is expected to be between 45% and 55%. However, for the purpose of this study the mean percentage of 50% will be applied to the estimate, due to the variability of figures throughout the current literature.<sup>132</sup> The estimated Shiite population is reduced to 2,112,000 with the application of the aggregate Shiite percentage. For this study, a population of Shiite youths must be extracted from the Shiite population. The final two calculations required to determine an estimated recruitment base will be the application of the age structure percentage

---

the-press/press-coverage-2006/july-2006/comparing-hezbollah-and-israels-military/?locale=en (accessed April 11, 2011); BBC NEWS, *BBC NEWS Middle East Quick guide: Hezbollah* (August 22, 2006) [http://news.bbc.co.uk/2/hi/middle\\_east/5262484.stm](http://news.bbc.co.uk/2/hi/middle_east/5262484.stm) (accessed April 11, 2011).

<sup>130</sup> Jane's World Insurgency and Terrorism database, *Hizbullah* (Mar 25, 2011) [http://jwit.janes.com/subscribe/jwit/doc\\_view\\_print.jsp?K@DocKey=/content/janesdata/bin](http://jwit.janes.com/subscribe/jwit/doc_view_print.jsp?K@DocKey=/content/janesdata/bin) (accessed April 9, 2011).

<sup>131</sup> Department of Economic and Social Affairs, *World Population Prospects: The 2008 Revision, Highlights* Working Paper No. ESA/WP.210, (Population Division, New York: United Nations, 2009), iii-87.

<sup>132</sup> Department of Economic and Social Affairs, *World Population Prospects*, 33, (see table A.1); Pew Research Center, *Mapping the Global Muslim Population A Report on the Size and Distribution of the World's Muslim Population*, (Washington, DC: Pew Forum on Religion & Public Life, October 2009), 10.

(15-64 years) and the sex ratio (number of males to 100 females) both obtained from the Central Intelligence Agency's *The World Factbook 2009*.<sup>133</sup> The age structure percentage is 67.1%, which now reduces the Shiite population number to approximately 1,417,000 – the number of young as well as middle aged Shiites potentially available for recruitment.<sup>134</sup> The final calculation is the application of the male percentage for the age structure of (15-64 years). This will determine the number of available male youths, as well as female youths, which can be specifically recruited. The male percentage for this age structure is approximately 48%, which yields 679,000 males to 738,000 females.<sup>135</sup> The initial bases of mobilization, the Shiite male youths, provide Hezbollah with an immediate pool to fulfill its initial tactical actions. However, Hezbollah must find ways to not only increase its recruitment base, but also most importantly, sustain its pool for long-term operations.

The use of electoral data is another method capable of providing insight into the size and scope of the Hezbollah's recruitment pool. The popular support for Hezbollah candidates during the 2000 South Lebanon election suggests that 786,657 or 30% of the disaffected voting population of 2,615,830 Shiites support Hezbollah.<sup>136</sup> The age range for this calculation is (21-64 years). Since Lebanese suffrage is 21, this population does not contain any young Lebanese males in the range of (15-20 years). To determine the approximate potential size of Hezbollah, the percentage of male voters, 48%, yields 376,900 males eligible for recruitment. This estimate

---

<sup>133</sup> Central Intelligence Agency, *The World Factbook 2009* (Washington, DC: Central Intelligence Agency, 2009), 362.

<sup>134</sup> Central Intelligence Agency, *The World Factbook 2009*, 362

<sup>135</sup> Ibid.

<sup>136</sup> Hamzeh, *In the Path of Hizbullah*, 117-118, (see table 5.7). The initial 30% Hezbollah popular support figure was determined by adding the total number of popular votes for all of the Hezbollah candidates (786,657) and dividing by the total number of Shiite votes (2,615,830) for the 2000 South Lebanon elections. Fourteen of twenty-three council seats were available for Shiites in South Lebanon and Nabatiyyah. Muhammad Ra'ad, Hezbollah party member, received the highest number of popular votes out of all Shiite candidates. All eligible Hezbollah party members were elected to four of the fourteen Shiite seats, or 29% of the available Shiite seats.

provides the upper bound for the potential recruitment pool from the disaffected male population.<sup>137</sup> The estimated size of Hezbollah based on published figures 30,500 and the estimated demographic population data 376,900 are both useful to this study for estimating the lower and upper bounds of the recruitment base.

## **Modeling**

The literature review of Hezbollah's recruitment process provides a broad understanding of the factors involved in terrorist recruitment. In this section, this monograph constructs a nonlinear, real valued autonomous system of four variables to model the Hezbollah recruitment process. The purpose of the model is to provide insight into the most and least effective methods of affecting the recruitment process. Computer modeling is used to identify phase space behavior of the system of equations.

## **Research Question**

How can the dynamics of a terrorist organization's recruitment operations be modeled as a set of coupled ordinary differential equations?

## **Hypothesis**

The Hezbollah Recruiter, like an enzyme, can increase the rate of conversion of the disaffected population into trained recruits, and subsequently into radical jihadists, without being consumed in the process. Modeling the interaction between key parameters affecting recruitment can provide insights into how to degrade the Recruiter's effectiveness and efficiency, which may limit Hezbollah's growth.

---

<sup>137</sup> The refined pool of potential Hezbollah recruits (376,900) was computed by multiplying the male percentage (48%) by the total number of popular votes for all of the Hezbollah candidates (786,657). The age ranges differ from the demographic data and electoral data due to voting age. To simplify further calculations, the potential male estimate from the electoral data, which is more conservative, will be used as the upper bound for the recruitment base.

## Model Construction

Many factors contribute to a terrorist organization's ability to recruit foot soldiers. In the previous sections, we saw that these factors can include economics, religious ideology, political ideology, and the acquisition and retention of territory. Some of these factors can cause growth or decay in the rate of recruitment. However, the recruiter is arguably the most significant and influential *mechanism* for generating a rapid mobilization base for a terrorist organization.

The role of a recruiter can be compared with a catalyst in a chemical reaction. A catalyst increases the rate of a chemical reaction without being consumed by the reaction.<sup>138</sup> Likewise, a recruiter can speed up the process of recruiting foot soldiers but is not transformed by the process. The rate and outcome of an enzymatic process depends on a number of environmental variables, such as temperature, volume of activation substance, and pressure. Likewise, the effective recruitment depends on key environmental variables, such as funding, education (religious ideology and/or guerrilla tactics), and the level of violence.

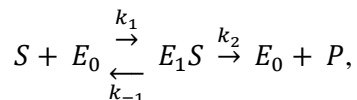
While there are many obvious differences between terrorist recruitment and chemical catalysis, exploring their similarities may provide a novel perspective for modeling terrorist recruitment dynamics. This model will address two questions. The first question is: what is the role of the recruiter, specifically how is the rate of recruitment related to the initial conditions and key environmental variables? The second question is: what levers are available to counterterrorist forces to disrupt and degrade terrorist recruitment?

We begin the process of model building by surveying existing biochemical models of enzyme kinetic reaction systems. Enzymes are complex proteins that carry out chemical reactions in cells faster than they would occur in their absence – they “selectively lower the energies of

---

<sup>138</sup> Irwin H. Segel, *Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems* (New York, NY: A Wiley-Interscience Publication, 1975), 6.

activation in the chemical reaction.”<sup>139</sup> Like all other catalysts, enzymes are not consumed by the reactions they catalyze. Enzyme kinetics is the study of rates of chemical reactions that involve enzymes. The following equation describes the enzyme kinetic reaction:<sup>140</sup>



where  $E_0$  consists of enzymes,  $S$  is the substrate,  $E_1S$  is the intermediate step product resulting from the combination of  $E_0$  and  $S$ , and  $P$  is the product. The reaction rates in the system are denoted by the positive constants of proportionality  $k_i$ , where  $i > 0$  represents the forward reaction and  $i < 0$  represents the reverse reaction.<sup>141</sup>

These processes are simply described as the interaction of a substrate binding to the active site of an enzyme, yielding an intermediate product.<sup>142</sup> The next step in the process disassembles the intermediate product, yielding the enzyme in its original state ready to combine with another substrate and a new molecular product.<sup>143</sup> An example of this process is illustrated by the fermentation of simple sugars into alcohol. This simple sugar reaction is a single rate equation: once the sugars have been converted by the enzyme to alcohol, the reaction is complete.

Another example of an enzyme kinetic reaction system is the transfer of nutrients in a bacterium. A single cell bacterium requires nutrients, such as simple sugars, transferred across its cellular wall in order to process the nutrients. The external nutrients can pass through the cellular membrane faster with the assistance of an enzyme with an active site available for binding. The

---

<sup>139</sup> Segel, *Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems*, 6.

<sup>140</sup> Hans Bisswanger, *Enzyme Kinetics: Principles and Methods*, trans. Leonie Bubenheim (Weinheim: Wiley-VCH, 2002), 55.

<sup>141</sup>  $E_0$  are the Recruiters,  $S$  are the Restless (recruiting population),  $E_1S$  are the Recruits (trained foot soldiers from recruiting population), and  $P$  are the Radicals (radicalized Recruits). The constants of proportionality for this model represent the parameters of education, funding, Recruiter training efficiency, non-suicide violence, and suicide violence.

<sup>142</sup> Bisswanger, *Enzyme Kinetics: Principles and Methods*, 55.

<sup>143</sup> Ibid.

simple sugars bind to the active sites available in the concentration of enzymes, allowing for rapid transfer through the cellular membrane (intermediate product), and facilitates rapid consumption by the bacterium for sustainment (product). Once the product has been produced inside the bacterium, the enzyme can reverse its transit through the cellular membrane and combine with another substrate in the external space, returning once again to the interior of the bacterium. The rates of reaction within this system are dependent on environmental parameters such as heat and light, which are assumed constant throughout the overall reaction. One reaction equation of particular interest is the Michaelis-Menten equation:<sup>144</sup>

$$K(n) = \frac{Kn}{A+n},$$

where  $K$  and  $A$  are positive constants of proportionality governing the rates of reactions in the system, and  $n$  is the concentration of the nutrient. The right-hand term  $K(n)$  is the cellular growth rate as a function of concentration. The Michaelis-Menten equation describes the linear aggregated reaction dynamic. However, the ordinary differential equations used to derive the Michaelis-Menten equations are:<sup>145</sup>

$$\begin{aligned}\frac{dn}{dt} &= (-k)nx_0 + k_{-1}x_1 \\ \frac{dx_0}{dt} &= (-k)nx_0 + k_{-1}x_1 + k_2x_1 \\ \frac{dx_1}{dt} &= k_1nx_0 - k_{-1}x_1 - k_2x_1 \\ \frac{dp}{dt} &= k_2x_1\end{aligned}$$

---

<sup>144</sup> Douglas D. Mooney and Randall J. Swift, *A Course in Mathematical Modeling* (The Mathematical Association of America, 1999), 314.

<sup>145</sup> Ibid., 316.



where  $k_i$  are constants of proportionality included in the rates of reaction,  $n$  is the concentration of the substrate,  $x_0$  is the concentration of the enzyme, and  $x_1$  is the concentration complex of the enzyme and substrate reactants.

Now that we have found a model for catalytic dynamics, these differential equations can be modified to represent terrorist recruitment processes. The key actors in terrorist recruitment are categorized as Restless, Recruiters, Recruits, and Radicals. The Restless are the Shiite youths that are available to be educated by Muslim clerics trained in Najaf, Iraq. The Recruiters are those Lebanese Shiites who have been trained by radical clerics, funded by external states, and have committed numerous non-suicide attacks against Israeli Defense Forces. The initial Recruiters into this system are those trainers from the Iranian Republic Guard Corps.<sup>146</sup> The Recruits are those Shiites of the Restless population that begin their indoctrination into the Hezbollah organization by receiving religious/military education and minor funding to begin non-suicide attacks against Israeli Defense Forces. The Radicals are those Recruits that have received the blessings from the radical clerics to conduct martyrdom operations, which consist of suicide attacks against Israeli Defense Forces. The key parameters that modify the rates of exchange between these populations are money, violence, and education.

Let  $X_1(t)$ ,  $X_2(t)$ ,  $X_3(t)$ , and  $X_4(t)$  denote the population level at time ( $t$ ) of the four populations of agents, the Restless, Recruiters, Recruits, and Radicals respectfully. We introduce a dimensionless time variable by setting  $\tau = kt$  in order to focus on the qualitative behavior of the population dynamics, rather than fixing the dynamics to a particular time scale. The rate of change for the different populations is given by the first derivative  $X'_1(\tau)$ ,  $X'_2(\tau)$ ,  $X'_3(\tau)$ , and  $X'_4(\tau)$  which is expressed with the simplified notation  $X'_1$ ,  $X'_2$ ,  $X'_3$ , and  $X'_4$  and referred to as the growth rate. The system of four equations below shows how the growth rate for each population

---

<sup>146</sup> Qassem, *Hizbullah: The Story from Within*, 137.

depends on the size of the four populations and the parameters representing money, violence, and education.

$$\begin{aligned}
\text{Restless } X'_1 &= (-m)x_1x_2 + umx_4 \\
\text{Recruiters } X'_2 &= \frac{1}{T}(-m)x_1x_2 + \frac{(e+m)x_3}{x_2} \\
\text{Recruits } X'_3 &= mx_1x_2 - \frac{(e+m)x_3}{x_2} - evx_3 \\
\text{Radicals } X'_4 &= evx_3 - umx_4
\end{aligned}$$

All constants are positive in this system, and are denoted by the following. The constant  $m$  represents money, the funding to train and equip agents in guerilla actions;  $e$  is the religious and military education from radicalized Shi'a clerics and Recruiters;  $T$  is the number of recruits that can be trained at the same time;  $v$  is the rate of non-suicide violence; and  $u$  is the suicide attack rate. The variable terms represent flows into and out of the populations. The variable term,  $mx_1x_2$ , represents the recruitment efficiency, given the funding rate  $m$ , of the Recruiters in the presence of the Restless: the Recruitment efficiency. The interaction term  $\frac{(e+m)x_3}{x_2}$  represents the rate at which Recruits are converted into Recruiters: the trained Recruiters efficiency. The interaction term  $evx_3$  represents the rate at which Recruits are converted into Radicals: the trained Radicals efficiency. The interaction term  $umx_4$  represents the rate at which Radicals conduct suicide attacks: the Radical suicide efficiency. One remaining interaction term  $\frac{1}{T}$ , the constant of proportionality, represents the Recruits to Recruiter ratio. This term limits the number of Recruits that can feasibly be trained by a number,  $\frac{1}{T}$ , of Recruiters in a cell. In the original Michaelis-Menten equations, an enzyme can only bond to one molecule nutrient at a time. This extension to the model allows the Recruiters to attach to more than one Recruit at the same time.

In summary, the growth of the Hezbollah organization is a function of the number of recruiters, the number of recruits, the success rate of previous attacks to stimulate recruitment, and both funding and education to support and execute all of these activities by the various

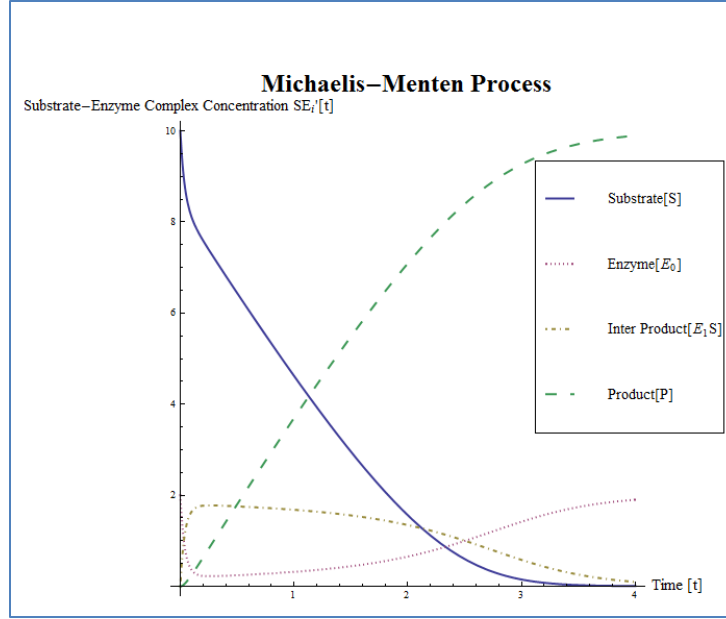
populations over time. Most importantly, the recruiter, like an enzyme, can significantly increase or decrease the rate of recruitment without being affected by actions to deter Hezbollah operations. When studying the Michaelis-Menten process, several conditions must be established to enable the translation of complex behavior into simplified mathematical analysis. For example, one enzyme can act on only one molecule at a time, temperature remains constant, and the concentration of the substrate must be greater than the concentration of the enzyme. Likewise, the model of recruitment must establish several conditions for ease of analysis. Recruiters will always be present in the system, and at time zero, there is already an established population of trained Recruits. Even with these assumptions, the system of equations are nonlinear and do not present simplified explicit solutions. Therefore, graphical analysis is required to examine the system's behavior and perform sensitivity analysis.

## **Analysis**

The use of graphs in dynamical modeling can be extremely useful in describing the numerical solutions of nonlinear ordinary differential equations qualitatively when explicit solutions are not possible. In this subsection, three kinds of analysis are performed. First, time graphs showing population sizes over time are analyzed. Next, phase space graphs, which depict solutions to the system of equations in three dimensional space, are analyzed to determine the maximum number of Radicals produced with different initial conditions for the number of Recruiters. Finally, the sensitivity of the model to the value of constants is analyzed.

### **Time Graphs**

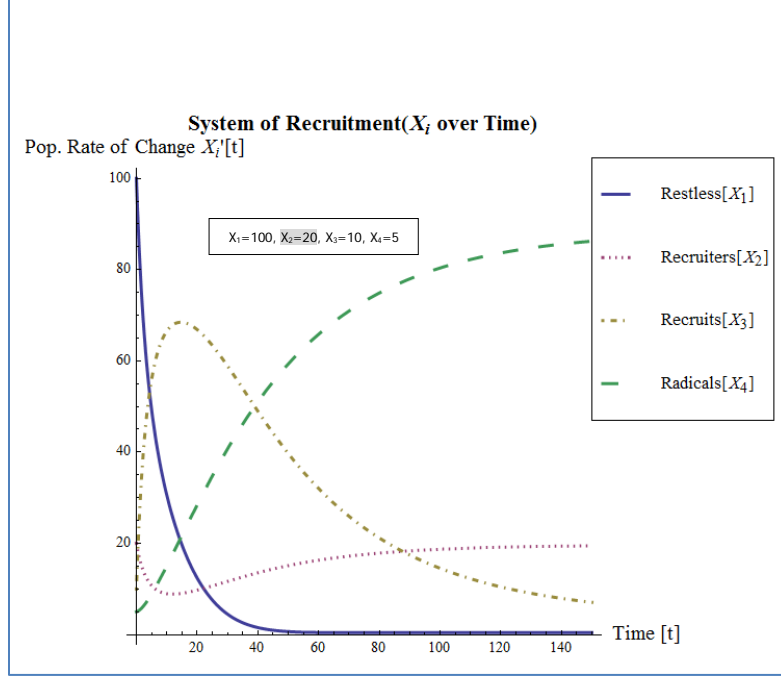
Since the recruitment model derives its underlying basis from the Michaelis-Menten equations, for the purpose of comparison, Figure 1 plots the change in concentration over time in this original system.



**Figure 1. Concentration over time for the Michaelis-Menten equations.**

Figure 1 illustrates the fundamental Michaelis-Menten kinetic interaction of the enzyme-substrate complex over time. As substrates are converted by enzymes  $E_0$  to the intermediate step product  $E_1S$ ,  $S$  demonstrates exponential decay. The formation of  $E_1S$  is restricted initially by the decreasing concentration of  $E_0$ , which is depicted by a dip in the graph near  $x = 0$  due to the combination of these two reactants. Once the concentration of  $E_0$  has reached its minimum value to support the reaction, logistic growth follows and  $E_0$  returns to its original level. As  $E_1S$  is produced, the second step of the reaction occurs forming the final product  $P$ , which grows at an approximately logarithmic rate. Additionally, due to the delay of the system by the limiting kinetic action of  $E_0$ , the graph of  $P$  depicts the formation of remaining the  $E_1S$  complex into the final product over time as  $E_1S$  approaches zero. The enzymes  $E_0$  have converted a concentration of complexes into another concentration of complexes without being consumed.

Figure 2 illustrates the change of model population levels over time in the Hezbollah recruitment process based on the concepts of kinetic enzyme-catalytic reactions.



**Figure 2. Hezbollah recruitment populations over time.**

Figure 2 illustrates the formation of the Radicals from the Restless population by the capabilities and resources of the Recruiters over time. Like the enzymes in the Michaelis-Menten processes, the Recruiters are not consumed throughout the process of supporting the formation of the Radical population. The capability of the Recruiters to conduct the recruitment process without being reduced allows the Hezbollah organization to grow through a sustained support base that is constantly supplying new personnel for the possible conversion into radical jihadists. The process of producing Radicals from the Restless is also like the two-step enzymatic kinetic reaction, only in this case the first step is focused on the formation of the intermediate step product, the Recruits  $X_3$  from the interaction of the Restless  $X_1$ , the Recruiters  $X_2$ , and the Radicals  $X_4$ . The second step is designed to produce the final product, the Radicals  $X_4$  from the interaction of the Recruiters  $X_2$  and Recruits  $X_3$ .

As the Restless  $X_1$  are converted into new Recruits  $X_3$ ,  $X_1$  demonstrates exponential decay. Unlike the system in Figure 1, the formation of new Recruits  $X_3$  is not restricted initially by the decreasing concentration of the Recruiters  $X_2$ , due to the parameter  $\frac{1}{T}$ , which permits  $X_3$  to

grow faster than  $X_2$  decays. Once the concentration of  $X_2$  has reached its minimum value to support the reaction, the curve then exhibits logistic growth back to its original level. As  $X_3$  is produced, the second step of the reaction occurs by forming the product, the Radicals  $X_4$ , which also grows at an approximately logarithmic rate. The final total value of all populations is conserved and is bounded by the initial population value of  $X_1$ . As  $X_1$  is depleted, this limits the possible growth of  $X_4$ . Subsequently, the population of  $X_4$  decreases over time as the population of Recruits  $X_3$  is depleted. The graphs illustrate how the Recruiters  $X_2$  converted a population of the Restless  $X_1$  into other populations useful to the Hezbollah organization, the Recruits  $X_3$  and the Radicals  $X_4$ , without being consumed during the process. Hezbollah is now equipped with the additional capabilities for sustaining and growing their organization. To understand the rate at which Recruiters can develop and recruit new members based on additional parameters, such as education, funding, non-suicidal violence, and suicidal violence, additional graphical analysis must be conducted. Because the initial values for this system have been arbitrarily selected, this monograph uses sensitivity analysis to test the generality of the results.

### Sensitivity Analysis: Phase Space Graphs

Sensitivity analysis of the system is an evaluation process focused on observing  $X'_i$ , the population growth rate equations, and their response to changes in initial conditions and the parameters  $m$ ,  $e$ ,  $T$ ,  $v$ , and  $u$ . Since exact solutions to nonlinear ordinary differential equations are generally unavailable, graphing the behavior of a solution provides qualitative insight into the solution of the system of equations. The graph used in this type of analysis is a phase portrait and it depicts the numerical solution of the equations in multiple dimensions, plotting  $x$  and  $y$  values against a third variable,  $z$ . The phase portrait of the recruitment process consists of the Restless, Recruiters, and Radicals. Recruits will not be represented in the phase portrait because the rate of production of the Radicals was found to be insensitive to the level of Recruits in experiments not included in this report. Compared with the population dynamics graphs in the previous section,

the phase portrait does not graph the variables over time, but rather in relation to one another. A point is plotted for every possible state of the system. The system's evolution over time is seen when these points form curves that trace a trajectory through phase space. Phase portraits provide information about different qualitative behaviors of the system by revealing attractors and bifurcations.

In the case of this model, the phase portrait maps a three-dimensional graph of the interactions between the Restless  $X_1$ , the Recruiters  $X_2$ , and the Radicals  $X_4$ .<sup>147</sup> This monograph specifically focuses its sensitivity analysis on five initial population cases for the Recruiters  $X_2 = 0, 1, 2, 20, 40$ . This enables it to analyze the effects of very small numbers of Recruiters, as well as the effect of doubling the number of Recruiters from the default initial condition  $X_2(0) = 20$ . The additional model parameters,  $m$ ,  $e$ ,  $T$ ,  $v$ , and  $u$ , will initially remain constant for all five cases. These parameters are adjusted to investigate their effects on the sensitivity of the system at the conclusion of the sensitivity analysis.

The sensitivity analysis consists of two graphs, a three-dimensional phase portrait and a two-dimensional graph of population over time. The first phase portrait is depicted in Figure 3 a. The black curve depicts the numerical solution of the system, with a large black sphere showing  $\tau = 0$  and a red triangle showing the limit of the system's trajectory. The colored vectors (gray scale in black and white) represent the direction and magnitude of the sensitivity of variables to perturbation at different points in phase space. The next five subsections vary the initial Recruiter population, beginning with  $X_2(0) = 0$ .

---

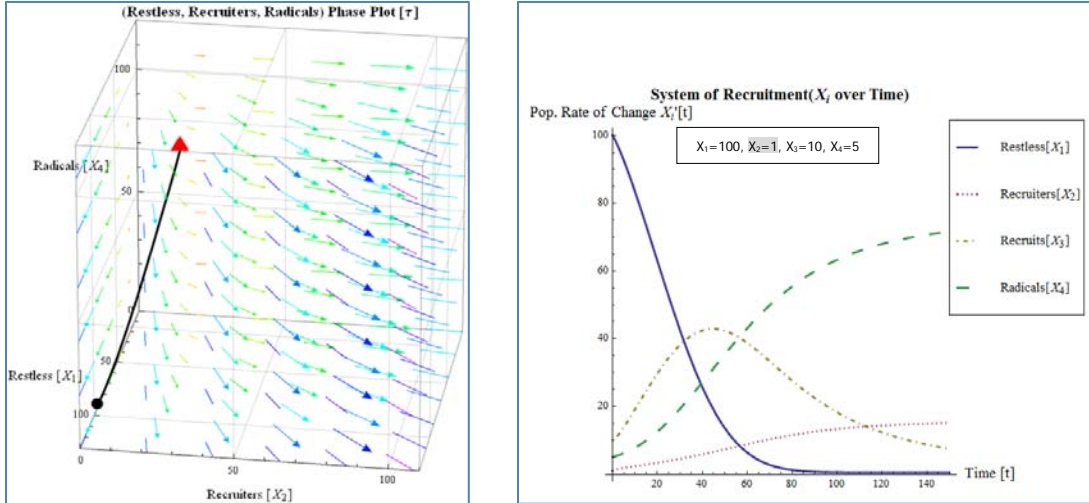
<sup>147</sup> The computer graphing software used to create the 3 dimensional phase plots and the 2 dimensional population over time plots was *Wolfram Mathematica 8: For Students*, Version 8.0.1.0. Programming code available upon request to the author.

### Case 1

When  $X_2(0) = 0$ , there are no Recruiters available to interact with the other populations. There is no solution available for the system; hence, no phase portrait is created for analysis. This result is interpreted as follows. The presence of Recruiters is a necessary condition for the recruitment process. Eliminating all recruiters in the terrorist organization prevents any further growth in the organization.

### Case 2

For  $X_2(0) = 1$ , Figure 3a and 3b provide a graphical illustration of the general behavior of this case. The flow of solutions along the curve begin at the black circle where  $X_1 = 100$ ,  $X_2 = 1$ , and  $X_4 = 5$ , and terminate at the red triangle where  $X_1 = 0$ ,  $X_2 = 13$ , and  $X_4 = 60$  (see Figure 3 a).



**Figure 3. (a) Phase Plot, initial value of  $X_2(0)=1$  for the Recruiters  $X_2$ ; (b)  $X_i$  over Time for  $X_2(0)=1$ .**

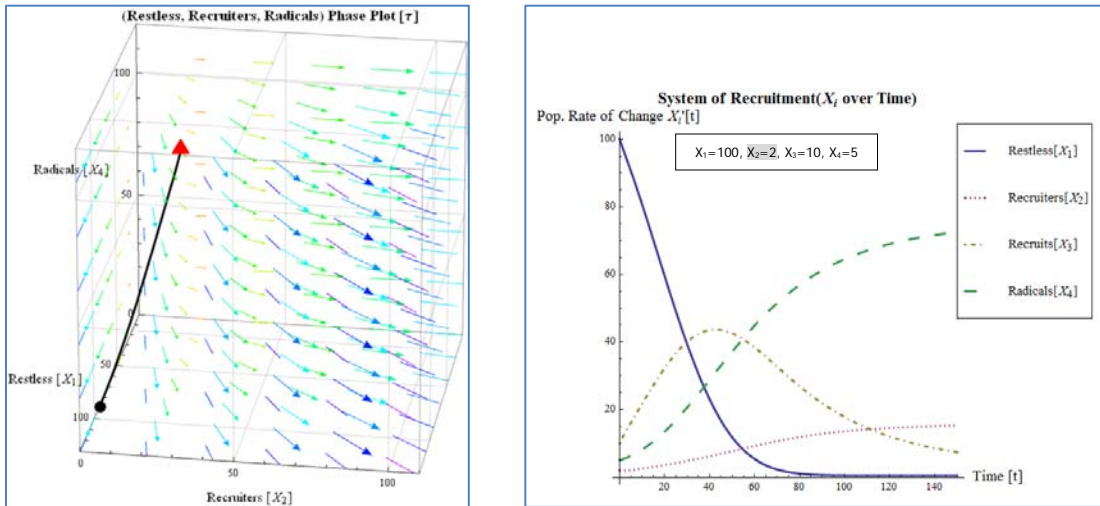
The solution curve is concave up and the vector arrows throughout the phase space vary in magnitude and direction in response to parameter sensitivity. In Figure 3b, the plot for the Recruiters increases beyond its initial population level unlike the “catalysts” in Figure 1 and in Figure 2. The “catalyst” or Recruiter begins at 1, yet exceeds this value at time 3 and continues to increase in value until reaching a Recruiter population of 16. This occurs for two reasons: first,



the Restless nutrient pool has reached zero, and second, the initial value of Recruits and Radicals begin to provide “pseudo-nutrients” for the Recruiters in the absence of the Restless. For recruitment and conversion to occur, the Recruiters must be present; hence the generation of additional Recruiters from secondary nutrient sources. The maximum number of Radicals produced in this case is 56. Figure 3b illustrates the time it takes to reach 90% of the maximum value of the Radical population, which is 50 at time 71. For cases 3-5, we will compare how fast the 90% level is reached, as well as the final 100% of the Radical population.

### Case 3

When  $X_2(0) = 2$ , the trajectory begins at the black sphere where  $X_1 = 100$ ,  $X_2 = 2$ , and  $X_4 = 5$ , and terminates at the large red triangle where  $X_1 = 0$ ,  $X_2 = 13$ , and  $X_4 = 61$  (see Figure 4a).



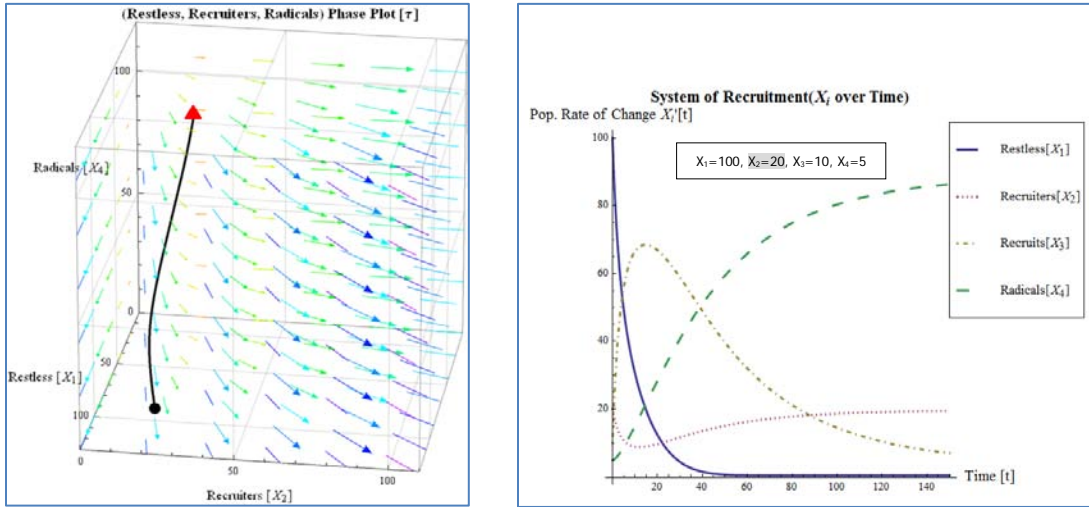
**Figure 4. (a) Phase Plot, initial value of  $X_2(0)=2$  for the Recruiters  $X_2$ ; (b)  $X_i$  over Time for  $X_2(0)=2$ .**

Compared with Case 2, the initial number of Recruiters has doubled from  $X_2 = 1$  to  $X_2 = 2$ , yet the final number of Radicals only increases from 56 to 57. The addition of one Recruiter has only generated one more Radical. Since Figure 4b illustrates the time it takes to reach 90% of the maximum value, we will compare how fast the 90% level is reached with one Recruiter and then with two Recruiters. In Figure 3b, the 90% value is 50 at time 71, while in

Figure 4b, 90% of the maximum value of Radicals, 51, is reached at time 70. Having two Recruiters enables the Radicals to reach 90% of their maximum value one-time increment earlier than with one Recruiter. At low levels of  $X_2$ , the rate and extent of growth in  $X_4$  is not sensitive to perturbation.

#### Case 4

When  $X_2(0) = 20$ , this is the baseline value used to establish the general behavior of the system during model construction. Figure 5a and 5b provide a graphical illustration of the general behavior of this case. As with Cases 2 and 3, the flow of solutions along the curve begins at the black circle where  $X_1 = 100$ ,  $X_2 = 20$ , and  $X_4 = 5$ , and terminates at the large red triangle where  $X_1 = 0$ ,  $X_2 = 18$ , and  $X_4 = 78$  (see Figure 5a).

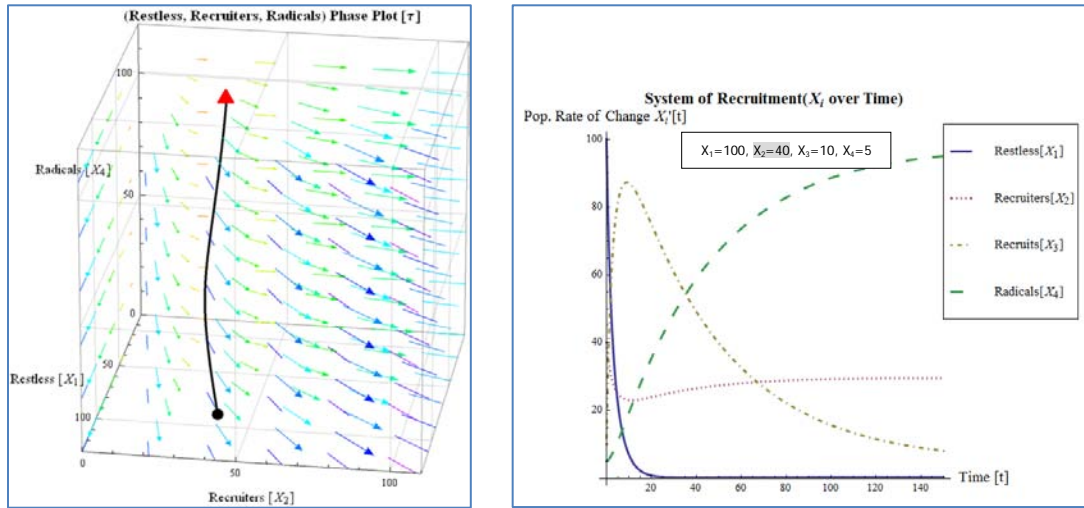


**Figure 5. (a) Phase Plot, initial value of  $X_2(0)=20$  for the Recruiters  $X_2$ ; (b)  $X_i$  vs. Time for  $X_2(0)=20$ .**

The maximum number of Radicals produced in this case is 75. Figure 5b illustrates the time it takes to reach 90% of the maximum value. In Figure 4b, two Recruiters achieve the 90% value (51) at time 70, while in Figure 5 b, 90% of the maximum value of Radicals (68) is reached at time 64. With 20 Radicals, the time to reach the 90% value is 9% faster while increasing the output of Radicals by 36%.

### Case 5

When  $X_2(0) = 40$ , Figure 6a and 6b provide a graphical illustration of the general behavior of this case. The flow of solutions along the curve begin at the black circle in which  $X_1 = 100$ ,  $X_2 = 40$ , and  $X_4 = 5$ , and terminate at the large red triangle where  $X_1 = 0$ ,  $X_2 = 29$ , and  $X_4 = 86$  (see Figure 6a).



**Figure 6. (a) Phase Plot, initial value of  $X_2(0)=40$  for the Recruiters  $X_2$ ; (b)  $X_i$  over Time for  $X_2(0)=40$ .**

The maximum number of Radicals produced in this case is 83. Figure 6b illustrates the time it takes to reach 90% of the maximum value; this monograph will compare how fast the 90% level is reached with 20 Recruiters. In Figure 5b, 20 Recruiters achieve the 90% value (68) at time 64, while in Figure 6b, 90% of the maximum value of Radicals (75) is reached at time 62. With 40 Recruiters, the time to reach the 90% value is 11% faster while increasing the output of Radicals by 50%.

### Sensitivity Analysis: Parameter Variation

In the previous five cases, the only variable that was adjusted in the construction of the graphs was the initial population level for the Recruiters  $X_2(0) = 0, 1, 2, 20, 40$ . However, the

value of constants representing the level of money, education, and violence can also affect the rate and quantity of the production of Radicals by the recruitment process.

Table 1 below consists of data generated from 735 iterations of parameter combinations from the NetLogo software package by fixing  $X_2 = 20$  for 731 iterations and modifying the initial values of the parameters by multiplying by a factor of 0.5 for the first set of criteria and then the parameters were multiplied by a factor of 2 for the second criteria.<sup>148</sup> The third set of criteria examined the effect of maintain the parameters at initial values and only adjusting the initial size of the Recruiters  $X_2(0) = 1, 2, 20, 40$ , for iterations 732-735. The baseline values were used as the fixed point for the sensitivity analysis.

Examining the data in Table 1, the first three rows provide the reader with the upper bound, the case where the most radicals were produced during the shortest period; the initial conditions as the fixed point for determining the variance in the data; and the lastly, the lower bound, which is the case where the least Radicals were produced during the longest period. The effects of the parameter values for the upper and lower bounds are intuitive. Doubling all of the parameters results in the largest number of Radicals, while halving all of the parameters, produces the fewest number of Radicals. Below these key data points for this experiment is a selection of cases sorted by the single parameter, variations that produced the largest degradation of the final Radical population. The cases are arrayed in parameter pairs, the low value 0.5 and the high value 2 applied to the respective parameter. The non-suicide violence parameter,  $v_{Low}$ , produced the greatest reduction in the final Radical population, with a value of 52. The ability of Recruiters to attain 90% of the final Radical population as early as possible is also degraded. Doubling  $v$  to

---

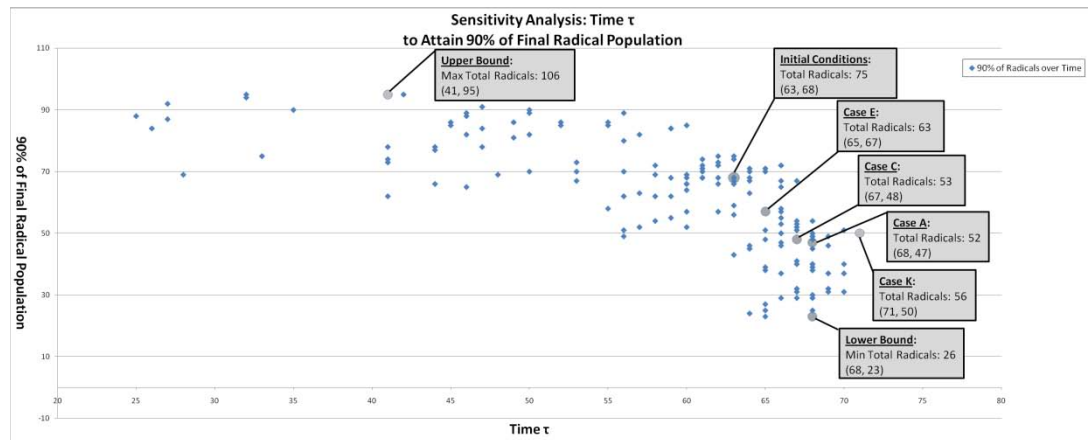
<sup>148</sup> Uri Wilensky, *NetLogo*, Center for Connected Learning and Computer-Based Modeling, Northwestern University, (1999) <http://ccl.northwestern.edu/netlogo/> (accessed September 5, 2010). “NetLogo is multi-agent programmable modeling environment,” which is designed for non-programmers (students and teachers outside of the computer science discipline) to examine complex adaptive systems. The program is written in Java and the code is designed for simple entry. In order to develop a random distribution and to investigate all combinations of three possible values for each of the five variables, 735 iterations were required to produce the data for analysis.

$v_{High}$  also produced the greatest increase in  $X_4(\infty)$  of all the parameter variations, and accelerated the rate of increase in  $X_4$ .<sup>149</sup> The next most sensitive response is  $e_{Low}$ , the education parameter, where the total Radical population value is 53. The 90% value of the total Radical population is 48 at time 67.  $X_2(0) = 1$ , illustrates the third most sensitive case, where the initial Recruiter population has been reduced to 1. The total Radical population value is 56, with the 90% value of the total Radical population listed at 50 for time 71. Of the variations of  $X_2(0) = i$ ,  $i = 0$  is trivially the best solution, however  $i = 1$  only has a moderate effect (compared with the baseline, it slows the rate of growth in Radicals, but is not the best way to reduce the final Radical population). The upper and lower bounds show the best strategy to counter recruitment is to engage all indirect influences simultaneously. The single parameter variations establish priorities for targeting in a resource-constrained environment. The negative slope of Figure 7 illustrates that generally parameter combinations that produce more radicals also produce them at a faster rate. Thus rate of growth in Radicals and the final Radical population are positively correlated.

**Table 1. Sensitivity Analysis from NetLogo Run.**

| Cases       | $X_2(0)$ | $v$ | $e$   | $T$ | $m$   | $u$  | Final Radicals $X_4$ | Time to Reach 90% of Final $X_4$ | Change in Final $X_4$ | Change in Time to 90% Final $X_4$ |
|-------------|----------|-----|-------|-----|-------|------|----------------------|----------------------------------|-----------------------|-----------------------------------|
| Upper Bd    | 20       | 0.8 | 0.1   | 10  | 0.005 | 0.05 | 106                  | 41                               | 40%                   | -35%                              |
| Baseline    | 20       | 0.4 | 0.05  | 5   | 0.01  | 0.1  | 75                   | 63                               | Baseline              | Baseline                          |
| Lower Bd    | 20       | 0.2 | 0.025 | 2.5 | 0.005 | 0.05 | 26                   | 68                               | -66%                  | 8%                                |
| $v_{Low}$   | 20       | 0.2 | 0.05  | 5   | 0.01  | 0.1  | 52                   | 68                               | -31%                  | 8%                                |
| $v_{High}$  | 20       | 0.8 | 0.05  | 5   | 0.01  | 0.1  | 94                   | 52                               | 25%                   | -17%                              |
| $e_{Low}$   | 20       | 0.4 | 0.025 | 5   | 0.01  | 0.1  | 53                   | 67                               | -29%                  | 6%                                |
| $e_{High}$  | 20       | 0.4 | 0.1   | 5   | 0.01  | 0.1  | 90                   | 49                               | 19%                   | -22%                              |
| $T_{Low}$   | 20       | 0.4 | 0.05  | 2.5 | 0.01  | 0.1  | 63                   | 65                               | -16%                  | 3%                                |
| $T_{High}$  | 20       | 0.4 | 0.05  | 10  | 0.01  | 0.1  | 80                   | 62                               | 6%                    | -2%                               |
| $m_{Low}$   | 20       | 0.4 | 0.05  | 5   | 0.005 | 0.1  | 74                   | 67                               | -1%                   | 6%                                |
| $m_{High}$  | 20       | 0.4 | 0.05  | 5   | 0.02  | 0.1  | 73                   | 60                               | -3%                   | -5%                               |
| $u_{Low}$   | 20       | 0.4 | 0.05  | 5   | 0.01  | 0.05 | 76                   | 61                               | 0%                    | -3%                               |
| $u_{High}$  | 20       | 0.4 | 0.05  | 5   | 0.01  | 0.2  | 73                   | 63                               | -3%                   | 0%                                |
| $X_2(0)=1$  | 1        | 0.4 | 0.05  | 5   | 0.01  | 0.1  | 56                   | 71                               | -26%                  | 13%                               |
| $X_2(0)=2$  | 2        | 0.4 | 0.05  | 5   | 0.01  | 0.1  | 57                   | 70                               | -25%                  | 11%                               |
| $X_2(0)=40$ | 40       | 0.4 | 0.05  | 5   | 0.01  | 0.1  | 83                   | 62                               | 10%                   | -2%                               |

<sup>149</sup> The infinity symbol,  $(\infty)$ , used in this notation represents the limit as  $t \rightarrow \infty$ .



**Figure 7. Sensitivity Analysis, 90% of Final Radical Population over Time.**

## Conclusion

Hezbollah's recruitment process replenishes its personnel and contributes to increased operational capability. By creating and extending its mobilization base, Hezbollah increased its operational reach across multiple lines of effort, such as social, political, military, and economic areas of action; hence, preventing its culmination over a 28 year period. The model shows rapidly declining recruitment base soon translates into declining growth in the Radical population. An implication of this model is that the declining recruiting base will be an important driver of terrorist adaptations. In the case of Hezbollah, this partly explains changes to Hezbollah's identity that broaden its appeal to a wider base of disaffected Lebanese youths and young adults beyond the Shiite male minority. To counter an increasing recruitment base, the model suggests indirectly targeting the recruitment system (the level of funding, education, and violence) as a more effective counterterrorism method than eliminating the Recruiters themselves.

The model of recruitment for this monograph results in a logistic growth curve for Radicals, since the growth of Radicals is limited by the combined initial size of the other three populations: Restless, Recruiters, and Recruits. One implication of this model is it provides a method for estimating the initial Restless population for Hezbollah. In the model, the Restless

population is quickly consumed by the recruitment process and converted them into Recruits and Radicals. In Section 3, we estimated the current size of Hezbollah at 30,500. According to the model, then, the initial number of Restless must be approximately equal to this figure. The upper bound for the recruitment base of Shiite male youths was 376,900. Therefore, the proportion of the recruitment base that is Restless – that is, willing to actively participate in a terrorist organization – is 8.0%. Our model and estimates suggest that for Hezbollah, approximately one in 12 Shiite youths are sufficiently disaffected to join a terrorist organization.

As demonstrated in this model of recruitment, the Recruiter, like an enzyme, can increase the rate of conversion of the base population into trained Recruits, and subsequently, into Radical jihadists without being consumed in the process. In Section 2, this monograph reviewed the literature and estimated the size of recruitment pool for Hezbollah as well as the current size of Hezbollah. In Section 3 the monograph constructed a model for how terrorist organizations convert the Restless into Recruits and Radicals. The model showed logistic growth, which quickly exhausted the available recruitment pool. Sensitivity analysis revealed the impact of varying the initial number of Recruiters, as well as the level of funding, education, and violence, on the effectiveness and efficiency of the recruitment process.

## **Recommendations**

The results from this study suggest that degrading a combination of the recruitment parameters, such as the reduction of non-suicide violence and education, slow the rate of growth and reduce the maximum number of Radicals produced by the recruitment system. The utility of the study allows for the prioritizing of the allocation of limited resources in a resource-constrained environment. The number one variable that affected the system with all other parameters fixed at initial conditions was the reduction of non-suicide violence,  $v_{Low}$ . Establishing security reduces the organization's ability to recruit from a stable population, and reduces the organization's core numbers through threat reduction operations. The second recommended

option would be targeting the parameter of education as represented in  $e_{Low}$ . The reduction of educational facilities, both religious and guerrilla, and/or those teachers that provide the instruction and training, would greatly degrade the recruitment and production of Radical insurgents. The third variable that had a significant affect with all other parameters fixed at initial conditions was the reduction of the Recruiter population,  $X_2(0) = 1$ . By reducing the number of Recruiters, the organization must decide how and what additional resources it must commit to the recruitment process, which may reduce its overall operational capability to conduct other activities over time. These recommendations may be obvious to counterterrorism experts; however, through sensitivity analysis of this dynamical system, the results suggest in order of effectiveness the parameters within the system that provide the greatest utility in combating terrorist recruitment and operations.

## **Monograph's Major Contributions and Implications**

This study is unique for three reasons: [1] it addresses an area that is seldom examined in terrorism research, the dynamics of recruitment; [2] it blends techniques from deterministic mathematical modeling with qualitative techniques of case study analysis from the political science discipline; and [3] it provides a novel model of recruitment based on enzyme kinetic dynamics. The study provides an example of applying multiple techniques to gain insights on a topic where reliable data is unavailable and previous research is sparse. This study provides specific implications for the military operational planner, such as an example of using an interdisciplinary approach to answer military research questions, and possible methods to induce shock into a system while maintaining economy of force.

## **Future Research**

Although this study uses a dynamical systems approach to investigate the dynamics of recruitment, further research may include an examination of a terrorist system of multiple



organizations; the inclusion of data in the classified realm to test for model fitness; or in the case of this study, inclusion of additional independent variables. The independent variables could be cooperating/competing populations, specific geographic/space operational zones, or specific phases of the organization's development. Additional branches of research from this study can and should be explored in order to develop a better understanding of these organizations and how to more effectively and efficiently counter them.

## Final Thoughts

In the case of Hezbollah, 28 years have passed and this organization has managed to survive by adapting to its environment and maintaining a robust mobilization base to counter Israeli/Lebanese policing, Israeli military forces, Syrian/Iranian politics, and perceived threats from Western States. Hezbollah's mobilization base of funding and education is sourced from the external state of Iran.<sup>150</sup> The Shiite community in southern Lebanon provides Hezbollah with the ways and means to achieve the organization's immediate ends of resistance to the occupation of Israeli Defense Forces and maintaining the resistance movement against Shiite oppression within the state of Lebanon.<sup>151</sup> Hezbollah's growth has been sustained by its ability to find new "nutrients," which in turn has broadened its base of support. The organization's growth in this study has been modeled to predict a logistics growth curve, which implies that over time Hezbollah must continue to find opportunities to increase its base in order to prevent culmination. The recruitment parameters that can be leveraged to either increase or decrease the recruitment process by the Recruiter should be a focus for the counterterrorist. An integrated, indirect approach is likely to be the most effective strategy to inhibit the growth of terrorist organizations.

---

<sup>150</sup> Qassem, *Hizbullah: The Story from Within*, 21; New TV, "Interview with New TV," 407.

<sup>151</sup> Azani, *Hezbollah: The Story of the Party of God*, 51, 61.

## BIBLIOGRAPHY

- Alagha, Joseph. *The Shifts In Hizbullah's Ideology: Religious Ideology, Political Ideology, and Political Program*. De Kreeft: Amsterdam University Press, 2006.
- Azani, Eitan. *Hezbollah: The Story of the Party of God: from Revolution to Institutionalization*. New York, NY: Palgrave MacMillan, 2008.
- Bar-Yam, Yaneer. *Dynamics of Complex Systems*. Westview Press, 2003.
- . *Making Things Work: Solving Complex Problems in a Complex World*. NECSI Knowledge Press, 2004.
- BBC NEWS. *BBC NEWS Middle East Quick guide: Hezbollah*. August 22, 2006.  
[http://news.bbc.co.uk/2/hi/middle\\_east/5262484.stm](http://news.bbc.co.uk/2/hi/middle_east/5262484.stm) (accessed April 11, 2011).
- Bisswanger, Hans. *Enzyme Kinetics: Principles and Methods*. Translated by Leonie Bubenheim. Weinheim: Wiley-VCH, 2002.
- Blanford, Nicholas. "Introduction." In *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*, edited by Nicholas Noe, translated by Ellen Khouri, 1-13. New York, NY: Verso, 2007.
- Central Intelligence Agency. *The World Factbook 2009*. Washington, D.C.: Central Intelligence Agency, 2009.
- Chamberlain, T. "Systems Dynamics Model of Al-Qa'ida and United States 'Competition.'" *Journal of Homeland Security and Emergency Management* 43, no. 14 (2007): 1-23.
- Clauset, Aaron, and Frederik W. Wiegel. "A Generalized Aggregation-Disintegration Model for the Frequency of Severe Terrorist Attacks." *arxiv.org*. January 25, 2010.  
[http://arxiv.org/PS\\_cache/arxiv/pdf/0902/0902.0724v2.pdf](http://arxiv.org/PS_cache/arxiv/pdf/0902/0902.0724v2.pdf) (accessed March 13, 2011).
- Collier, Paul, and Nicholas Sambanis. *Understanding Civil War: Evidence and Analysis*. Vols. II: Europe, Central Asia, and Other Regions. II vols. Washington, D.C.: The World Bank, 2005.
- Collier, Paul, and Nicholas Sambanis. *Understanding Civil War: Evidence and Analysis*. Vol. I: Africa. II vols. Washington, D.C.: The World Bank, 2005.
- Collier, Paul, Anke Hoeffler, and Nicholas Sambanis. *The Collier-Hoeffler Model of Civil War Onset and the Case Study Project Research Design*. Vols. II: Europe, Central Asia, and Other Regions, chap. 1 in *Understanding Civil War: Evidence and Analysis*, Edited by Paul Collier and Nicholas Sambanis, 1-34. Washington, D.C.: The World Bank, 2005.
- Cook, Paul F., and W. W. Cleland. *Enzyme Kinetics and Mechanism*. New York, NY: Garland Science Taylor & Francis Group, LLC, 2007.
- Cox, Dan G., John Falconer, and Brian Stackhouse. *Terrorism, Instability, and Democracy in Asia and Africa*. Lebanon, NH: Northeastern University Press, 2009.
- Department of Economic and Social Affairs. *World Population Prospects: The 2008 Revision, Highlights*. Working Paper No. ESA/WP.210, Population Division, New York: United Nations, 2009.
- Dorner, Dietrich. *The Logic of Failure: Recognizing and Avoiding Error in Complex Situations*. Translated by Rita Kimber and Robert Kimber. Cambridge, MA: Perseus Books, 1996.

- Farley, Jonathan David. "Evolutionary Dynamics of the Insurgency in Iraq: A Mathematical Model of the Battle for Hearts and Minds." *Studies in Conflict & Terrorism* 30 (2007): 947-962.
- Gutfraind, Alexander. "Terrorism as a Mathematical Problem." *SIAM News*, October 2009.
- Gutfraind, Alexander. "Understanding Terrorist Organizations with a Dynamic Model." *Studies in Conflict & Terrorism* 32 (2009): 45-59.
- Hamzeh, Ahmad Nizar. *In the Path of Hizbullah*. 1st ed. Syracuse, NY: Syracuse University Press, 2004.
- Hannity, Sean, and Alan Colmes. "Barak: Israel's Presence in Lebanon Produced Hezbollah - Hannity - FoxNews.com." *FOXNews.com*. Edited by Inc. Voxant. July 26, 2006. <http://www.foxnews.com/story/0,2933,205726,00.html> (accessed March 30, 2011).
- Harik, Judith Palmer. *Hezbollah: The Changing Face of Terrorism*. New York, NY: I. B. Tauris & Co. Ltd, 2005.
- Hizbullah. "Hizbullah: Statement of Purpose." *Al-Mashriq - the Levant - Lebanon and the Middle East*. Edited by Borre Ludvigsen. Ostfold College. March 20, 1998. <http://almashriq.hiof.no/lebanon/300/320/324/324.2/hizballah/statement01.html> (accessed January 16, 2011).
- . *Hizbullah: Views and Concepts*. Edited by Borre Ludvigsen. Ostfold College. June 20, 1997. <http://almashriq.hiof.no/lebanon/300/320/324/324.2/hizballah/hizballah-background.html> (accessed January 5, 2011).
- . *Islamic Resistance In Lebanon*. Hizbullah. June 9, 2010. <http://english.moqawama.org/> (accessed June 9, 2010).
- Hoffman, Bruce. *Inside Terrorism*. 2nd Edition. New York, NY: Columbia University Press, 2006.
- Jackson, Brian A., John C. Baker, Kim Cragin, John Parachini, Horacio R. Trujillo, and Peter Chalk. *Aptitude for Destruction: Volume 1: Organizational Learning in Terrorist Groups and Its Implications for Combating Terrorism*. Vol. 1. Santa Monica, CA: RAND Corporation, 2005.
- . *Aptitude for Destruction: Volume 2: Case Studies of Organizational Learning in Five Terrorist Groups*. Vol. 2. Santa Monica: RAND Corporation, 2005.
- Jane's. *Hizbullah*. Mar 25, 2011. [http://jwit.janes.com/subscribe/jwit/doc\\_view\\_print.jsp?K@DocKey=/content/janesdata/bin](http://jwit.janes.com/subscribe/jwit/doc_view_print.jsp?K@DocKey=/content/janesdata/bin) (accessed April 9, 2011).
- Jones, Seth G., and Martin C. Libicki. *How Terrorist Groups End: Lessons for Countering al Qaeda*. Pittsburgh, PA: RAND Corporation, 2008.
- Judkins, Jr., James C. *The Expanding Role of the Shi'a in Lebanon*. Master's Thesis, U.S. Army Command and General Staff College, Fort Leavenworth, KS: U.S. Army Command and General Staff College, 1983, 1-139.
- Memon, Nasrullah, Jonathan D. Farley, David L. Hicks, and Torben Rosenorn. *Mathematical Methods in Counterterrorism*. Norderstedt: SpringerWienNewYork, 2009.
- Miller, John H., and Scott E. Page. *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*. Princeton, NJ: Princeton University Press, 2007.
- Mitchell, Melanie. *Complexity: A Guided Tour*. New York, NY: Oxford University Press, 2009.

- Mooney, Douglas D., and Randall J. Swift. *A Course in Mathematical Modeling*. The Mathematical Association of America, 1999.
- Nasrallah, Sayyed Hassan. "Full speech of H. E. Sayyed Nasrallah : Hizbullah's New Political Manifesto.. We Want Lebanon Strong & United." *www.english.moqawama.org*. November 30, 2009.  
<http://www.english.moqawama.org/essaydetails.php?eid=9632&cid=231&st=Political>  
 Document (accessed March 14, 2011).
- New TV. "Interview with New TV." In *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*, edited by Nicholas Noe, translated by Ellen Khouri, 378-410. New York, NY: Verso, 2007.
- Noe, Nicholas, Editor. *Voice of Hezbollah: The Statements of Sayyed Hassan Nasrallah*. Translated by Ellen Khouri. New York, NY: Verso, 2007.
- Norton, Augustus Richard. *Hezbollah: A Short History*. Princeton, NJ: Princeton University Press, 2007.
- Pew Research Center. *Mapping the Global Muslim Population*. A Report on the Size and Distribution of the World's Muslim Population, Washington, D.C.: Pew Forum on Religion & Public Life, October 2009.
- Qassem, Naim. *Hizbullah: The Story from Within*. Translated by Dalia Khalil. London: Saqi, 2005.
- Reich, Walter, Editor. *Orgins of Terrorism: Psychologies, Ideologies, Theologies, State of Mind*. Washington, DC: Woodrow Wilson Center Press, 1998.
- Richards, Diana, Editor. *Political Complexity: Nonlinear Models of Politics*. Ann Arbor, MI: The University of Michigan Press, 2001.
- Richards, Diana. "Spatial Correlation Test for Chaotic Dynamics in Political Science." *American Journal of Political Science* 36, no. 4 (November 1992): 1047-1069.
- Rueda, Edwin O. *New Terrorism? A Case Study of Al-Qaida and the Lebanese Hezbollah*. Master's Thesis, Naval Postgraduate School, Monterey, CA: Naval Postgraduate School, 2001, 110.
- Sageman, Marc. *Understanding Terror Networks*. Philadelphia, PA: University of Pennsylvania Press, 2003.
- Sambanis, Nicholas. *Conclusion: Using Case Studies to Refine and Expand the Theory of Civil War*. Vols. II: Europe, Central Asia, and Other Regions, chap. 10 in *Understanding Civil War: Evidence and Analysis*, Edited by Paul Collier and Nicholas Sambanis, 299-330. Washington, D.C.: The World Bank, 2005.
- Sambanis, Nicholas. "Terrorism and Civil War." Chap. 6 in *Terrorism, Economic Development, and Political Openness*, Edited by Philip Keefer and Norman Loayza, 174-206. New York, NY: Cambridge University Press, 2008.
- Saperstein, Alvin M. "'The Enemy of My Enemy Is My Friend' Is the Enemy: Dealing with the War-Provoking Rules of Intent." *Conflict Management and Peace Science*, 2004: 287-296.
- Segel, Irwin H. *Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems*. New York, NY: A Wiley-Interscience Publication, 1975.

- Senge, Peter M. *The Fifth Discipline: The Art and Practice of the Learning Organization*. Revised Edition. New York, NY: Currency Doubleday, 2006.
- The International Institute for Strategic Studies. "July 17th--BBC NEWS--Middle East Violence: Comparing Hezbollah and Israel's Military Strengths." *International Institute for Strategic Studies*. July 17, 2006. <http://www.iiss.org/whats-new/iiss-in-the-press/press-coverage-2006/july-2006/comparing-hezbollah-and-israels-military/?locale=en> (accessed April 11, 2011).
- Tilly, Charles. "The Politics of Collective Violence." 2003. <http://catdir.loc.gov/catdir/samples/cam034/2002074067.pdf> (accessed March 20, 2011).
- Triandafilloy, Vladimir K. *The Nature of the Operations of Modern Armies*. Edited by Jacob W. Kipp. Portland, OR: Frank Cass, 1994.
- Tsvetovat, Maksim, and Kathleen M. Carley. "On Effectiveness of Wiretap Programs in Mapping Social Networks." *Computational and Mathematical Organization Theory* 13, no. 1 (2007): 63-87.
- Turabian, Kate L. *A Manual for Writers: of Research Papers, Theses, and Dissertations*. 7th Edition. Chicago, IL: Chicago University Press, 2007.
- U.S. Department of Commerce. *Near East/South Asia Report Lebanon: Hizballah Issues 'Open Letter' on Goals, Principles*. Report, Foreign Broadcast Information Service, Springfield, VA: National Technical Information Service, 19 April 1985.
- Udwadia, Firdaus, George Leitmann, and Luca Lambertini. "A Dynamical Model of Terrorism." *Discrete Dynamics in Nature and Society* (2006): 1-32.
- Wilensky, Uri. *NetLogo*. Center for Connected Learning and Computer-Based Modeling, Northwestern University. 1999. <http://ccl.northwestern.edu/netlogo/> (accessed September 5, 2010).